

UNIVERSITY OF BRISTOL



THE ANNUAL REPORT

OF THE

Agricultural and Horticultural
Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL
1946

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* Transferred to Soil Survey Service 1/10/46.

† Transferred to National Agricultural Advisory Service 1/10/46.

CONTENTS.

	PAGE
INTRODUCTION	<i>T. Wallace, Director</i> 7
FRUIT AND VEGETABLE CULTURE :—	
Progress report on fruit breeding	<i>G. T. Spinks</i> 20
Cover crops in relation to soil fertility and tree nutrition. An experiment with bush cider trees. Progress report I	<i>C. Bould</i> 23
A manurial experiment on blackcurrants. Progress report I. <i>C. Bould and E. Catlow</i> ..	31
A technique for large scale pot sand cultures	<i>E. J. Hewitt</i> 37
Placement experiments in the use of fertilisers. Progress report, 1945 and 1946 <i>E. J. Hewitt and W. R. Stanton</i> ..	43
The resolution of the factors in soil acidity : some effects of manganese toxicity <i>E. J. Hewitt</i> ..	50
Some effects of lime and fertilisers on potatoes on a strongly acid soil as determined by visual symptoms and chemical tests <i>T. Wallace, W. Morley Davies, D. J. D. Nicholas and E. J. Hewitt</i> ..	61
Experiments on the control of magnesium deficiency in glasshouse tomatoes. IV. Concluding report <i>D. J. D. Nicholas and W. R. Stanton</i> ..	66
The use of growth substances to inhibit the sprouting of potatoes in storage <i>L. C. Luckwill</i> ..	79
PLANT PATHOLOGY :—	
Rain resistance of winter washes <i>S. H. Bennett, H. G. H. Kearns and H. Martin</i> ..	85
A note on the action of metaldehyde on slugs	<i>A. Stringer</i> 87
A note on the resistance of <i>Solanum polyadenium</i> to aphids	<i>A. Stringer</i> 88
The bean seed fly <i>Chortophila cilicrura</i> Rond.	<i>Mary Miles</i> 89
Chocolate spot of field beans in the South-West <i>L. Ogilvie and Moira Munro</i> ..	95
Progress report on hop disease investigations in the West Midlands <i>E. H. Wilkinson</i> ..	100
Soil conditions in relation to nettlehead of hops in the West Midlands. Progress report, 1946	<i>J. A. H. Tolhurst</i> 105
A preliminary survey of the insects associated with hops in the West Midlands in 1946	<i>J. F. Southey</i> 112
FRUIT AND VEGETABLE PRODUCTS :—	
Cider apple production in Herefordshire : results from Burghill trial orchard 1931-46 <i>C. Savidge</i> ..	116
The determination of the titratable acidity of apple juice and cider <i>L. F. Burroughs</i> ..	127
The apple as a source of vitamin C. Tests in 1946 <i>Margaret Kieser and A. Pollard</i> ..	132
The organic acids of some common fruits	<i>Joan D. Bryan</i> 138
Progress report on domestic apple juice production <i>Alice Crang, Dilys James and Margaret Sturdy</i> ..	140

CONTENTS—continued.

The retention of ascorbic acid and riboflavin in preserved vegetables		
	<i>Alice Crang, Dilys James, and Margaret Sturdy</i>	145
A note on bottled cucumbers ..	<i>Alice Crang, Dilys James and Margaret Sturdy</i>	152
The keeping quality of chutneys	<i>Alice Crang and Margaret Sturdy</i>	153
A comparison of five methods of making tomato juice	<i>Alice Crang and Margaret Sturdy</i>	156
Factors affecting quality in potatoes. III		
	<i>A. Pollard, Margaret Kieser and Alice Crang</i>	158

ADVISORY AND EDUCATIONAL WORK:—

Bristol University Agricultural Advisory Centre 1912-46 ..	<i>R. W. Marsh</i>	167
Report on advisory work 1945-46		180

PUBLICATIONS		183
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INTRODUCTION.

By T. WALLACE, C.B.E., M.C., D.Sc., F.R.I.C.

The year 1946 has witnessed further developments in the post-war policy and programme of the Station, among which must be mentioned the reconstitution of the Cider Advisory Committee which was first appointed in 1939 but whose activities were curtailed during the war period, the re-organisation of the scientific staff of the Cider Section and the extension of the research team in Plant Pathology. A further notable event during the year was the inauguration of the National Agricultural Advisory Service on October 1st, which terminated the University Advisory Service in Agriculture and Horticulture which had functioned without a break since 1912.

These events are likely to have important effects on the work of the Institute. The Cider Advisory Committee should prove of great value in connexion with cider research. It consists of representatives of the National Association of Cider Makers, the National Farmers' Union, County Councils contributing to the Institute, members of the National Fruit and Cider Institute and the Bath and West and Southern Counties Agricultural Society. The chairman is Captain D. M. Wills, chairman of the Station Finance and Business Sub-Committee and Treasurer of the National Fruit and Cider Institute. The committee is thus representative of all interests connected with the cider industry and with educational and research activities in cider making and cider orcharding. Its main functions are to advise the Finance and Business Sub-Committee on all matters relating to cider making and cider orcharding and on the programme of research. The reorganised committee held its first meeting on April 10th, when it appointed three sub-committees as under to carry out its main functions : (1) cider manufacture, (2) cider orcharding and fruit supplies, (3) research programme. With this organisation it is hoped that the main body will not need to hold more than one meeting annually, and it has been suggested that for this purpose a date in late July will be most suitable. The sub-committees have all met and will present their first reports to the main committee in July, 1947.

The scientific staff of the cider section had become depleted during the war years due to the retirement of Professor Barker and the resignations of Dr. Charley and Mr. Sills. Three new appointments have now been made to cover the subjects of microbiology, chemistry and cider orcharding, and with Professor Barker, working in a part-time capacity, to guide the team, it is hoped that steady progress in the new programme will soon be recorded.

The plant pathology group has been strengthened by the appointment of a physical chemist, a second mycologist, and an entomologist to study field problems of spraying machines and equipment. These appointments should enable comprehensive studies to be made of factors affecting the efficiency of sprays and dusts and of methods of application to fruit crops.

The establishment of the National Agricultural Advisory Service brought with it several changes. In the first place there was the break with the old organisation in the Department, in which research and advisory work had proceeded side by side and indeed were often almost indistinguishable. Under the new arrangement the staff of the research station ceased to be directly concerned with advisory problems dealt with by the N.A.A.S., and their whole time became available for research. The Institute, however, continues to

act as an advisory centre for problems relating to Cider and Perry manufacture and to cider-orcharding, for which subjects there are no specialist advisers at present appointed in the N.A.A.S. It should be noted, however, that there is close collaboration between officers of the N.A.A.S. and members of the staff of the Institute and that the specialist knowledge of the latter is still freely available to growers through the advisory officers.

The arrangements for collaboration as above in the South West Province are rendered easy by the fact that the new advisory centre at Bracken Hill, Leigh Woods, is within 3 miles of the Research Station, and the advisory officers maintain close touch with the work of the Station through attendance at staff discussions. Since the library facilities at Bracken Hill are likely to be very limited for some time, arrangements have been made for the full use of the Long Ashton library by the advisory officers.

As a means of welcoming the advisory staff into their new home and of ensuring that they should have an opportunity of meeting the staff of the Research Station a joint dance and social was held on 25th January, 1947, in the Hall of the Merchant Venturers' Technical College, by kind permission of the Principal, Professor Andrew Robertson, F.R.S. The Vice-Chancellor and Lady Morris were present and the Vice-Chancellor gave a warm welcome to Mr. Ross and his staff, in which he expressed the hope that the relations between the Advisory Centre and the University Departments with interests in Agriculture would be very close and that the staffs of Bracken Hill and Long Ashton would work together for the benefit of Agricultural and Horticultural interests in the area. It is proposed to make the dance an annual function, which should ensure that the two staffs have at least one opportunity each year of meeting together on a social occasion.

The establishment of the new service had made it necessary to revise the membership scheme of the National Fruit and Cider Institute in respect of advisory services at Long Ashton. Hitherto members have been able to obtain advice direct from the Research Station staff on any subject dealt with at the Station. Under the new arrangement, the Institute will only give advice regarding Cider and Perry, and members will obtain advice on the other subjects through the Advisory Centres. To provide for this point the membership scheme has been revised by the Station Finance and Business Sub-Committee and the draft approved by the Agricultural Research Council and the Ministry of Agriculture. It will be considered at the annual meeting of members of the National Fruit and Cider Institute in July, 1947, and in its final form will come into operation from January 1st, 1948.

The establishment of the N.A.A.S. also necessitated the departure of many members of the Advisory staff of the Department from the University. A full list of these is given in the report on advisory work (see p. 180).

It will be noted that most of those concerned in the change transferred to the new service and many have remained in the Bristol area. The best wishes of the Long Ashton staff go with their old colleagues in their new posts. We wish them every success in their future work. In particular, we should like to mention those who have served in the Department for many years and to assure them that we shall follow their new careers with special interest: Professor A. W. Ling, Principal of Seale Hayne Agricultural College, Newton Abbot; Mr. J. O. Jones, Advisory Chemist, South Eastern Province; Dr. D. A. Osmond, Soil Survey Officer, Rothamsted Experiment Station; Mr. E. L. Smith, Assistant Advisory Chemist, South Western Province; Mr. J. W. Egdell, Dairy Bacteriologist, South Western Province; Mr. D. W.

Menzies, Animal Health Division, Ministry of Agriculture and Fisheries; Dr. H. W. Miles, Deputy Provincial Director, West Midlands Province; Mr. L. Ogilvie, Provincial Advisory Mycologist, South Western Province; Dr. H. E. Croxall, Assistant Advisory Mycologist, West Midlands Province.

With the closing down of the advisory work of the Department it has been considered of interest to summarise the advisory work since its beginning in 1912. This has been done by Mr. Marsh and the account appears on p. 167.

During the year the Department lost by death one of its oldest friends, Mr. John H. Wootton, Byford, Herefordshire, who had been associated with the work of the National Fruit and Cider Institute since its formation in 1903.

By the death of Mr. Wootton the National Fruit and Cider Institute has lost the last member of its original Governing Body. Elected at the first Annual General Meeting as a representative of the Members and Associates of the Institute, he continued to serve in that capacity without a break until 1944, when advancing years were responsible for his retirement. In 1911 he was appointed on the Managing Committee of the Institute and *ipso facto* a year later, when the Institute was formally associated with the University of Bristol in a union resulting in due course in the establishment of the Department of Agriculture and Horticulture, he became a member of the Agricultural Committee of the University. His membership of that body extended until 1934-35.

In those various capacities his practical experience as a farmer, fruit grower and cider maker alone would have made him a useful asset for the work of the Research Station. In point of fact it was in directions apart from Committee work and not generally known that he rendered the Institute valuable service to a degree equalled by few during the course of its existence. His intimate knowledge of the farm orchards of Herefordshire and its adjacent counties, of the orchard and vintage qualities of the cider apples and perry pears of the region, and of the methods of cider making practice in that area gained in the course of his career as a County Instructor in farm orcharding and cider making, enabled him to keep the staff of the Institute fully informed in those matters from the start of its activities. His profound belief in the future of cider as a popular national drink, even at that remote time, made him an ardent enthusiast on the subject and his unremitting advocacy of the need for scientific research upon it was an important factor in securing the continued financial support of his county for the work at Long Ashton at a very critical period in its early history. His help in other ways, too numerous to specify, must be gratefully acknowledged as well as his frank and outspoken criticism of any feature of the work not in accordance with his own convinced opinions. He will be remembered particularly for his insistence on the need for the use of the true crab rootstock for farm orchard trees to ensure the greatest degree of hardiness and longevity, a point which indicated clearly his firm belief that the future advance of the cider industry would depend upon a sound farm orcharding system.

In previous reports, reference has been made to the serious lack of accommodation at Long Ashton. The departure of the Advisory officers in October eased the congestion to a slight extent by freeing three laboratories. The vacant rooms were allocated to the Cider, Plant Pathology and Mineral Nutrition Sections and have been suitably furnished and equipped for their new uses. The remaining congestion seems likely to be greatly eased during 1947, as a beginning has been made on the new Biology building which it is hoped to complete by the autumn of 1947. No further progress has been

made in obtaining a building to serve as a canteen, although this requirement is still regarded as of great urgency.

Serious consideration has been given to the best means of providing suitable accommodation for carrying out experimental work on cider. The old cider factory building is now seriously out-of-date, and it seems impossible to modify it to make it suitable for certain kinds of modern experimental work. It is considered that the problem would be best solved by the provision of a separate Cider Experiments building which would be specially designed for small-scale experiments (up to factory pilot scale) and to meet the requirements necessary for exact microbiological investigations. Plans and specifications for the building are in course of preparation, and it is hoped that they will soon be ready for submission to the Agricultural Research Council and the Ministry of Agriculture for approval. It must be emphasised that until a building of this type is available it will be impossible for the cider team to make substantial progress with factory problems.

After the serious failure of the fruit crop in 1945 it is gratifying to be able to report a satisfactory crop in 1946, although the wet and windy nature of the season rendered the quality below normal and seriously hampered work, and in particular harvesting operations.

A feature of the season's crops were the heavy yields obtained from the black currant varieties Mendip Cross and Cotswold Cross, both raised by Mr. Spinks at Long Ashton. As both varieties are being grown under various systems of manuring, considerable information should be available regarding the cropping powers of these two promising sorts during the course of the next few years.

Good progress can be reported in the research work carried out during the year, the salient points of which are recorded later in this report. The abnormally wet, windy and sunless nature of the season made it unfavourable for certain of the field experiments, owing to the adverse effects produced on the quality of tree fruits and the difficulties entailed in harvesting.

On the advisory side it will be noted from the statistics given on p. 180, that the volume of work in the last year of the advisory service was well maintained and indeed the year ranks as second to 1943 with regard to the number of enquiries received.

The memoir on Land Classification of the counties of Gloucester, Somerset and Wiltshire, referred to in the 1945 report, has been completed and should be published by the University of Bristol Reconstruction and Research Group during 1947.

During the year financial provision for the work in progress has been satisfactory, and it has been possible to pursue a full programme of research and advisory work.

It is also gratifying to report a record increase in membership of the Long Ashton Institute for which thanks are due to many old members who continue to help by bringing the work of the Station to the notice of their friends and others interested in horticulture.

BRISTOL ADVISORY CENTRE.

There is little of note to report in the work of the Advisory Centre. Although plans had been made for the cessation of work at the centre on September 30th, 1946, advisory work continued at high pressure until that date, and as already stated, the number of enquiries almost constituted a record in the history of the centre.

The transfer of the work of the various sections from Long Ashton and Berkeley Square began in early October, but since there were special difficulties in the rapid transfer of the Veterinary and Dairy Bacteriology Sections, the University consented to house them at Berkeley Square until the moves could be conveniently made. The Veterinary Section finally moved to Bracken Hill in February 1947, but the Dairy Bacteriology Section has not yet been transferred.

On the closing down of the centre, the Finance and Business Sub-Committee, on behalf of the Agricultural Committee of the University, conveyed to the head of each advisory section, the thanks of the Committee for the splendid work and loyal service of all grades of staff and wished them all success in their future careers.

LONG ASHTON RESEARCH STATION.

Staff.

During the year four senior appointments were made to the scientific staff.

Dr. S. W. Challinor was appointed as microbiologist in the Cider Section. The work in this subject had been carried on by Professor Barker since the retirement of Mr. Grove in 1933, but in the reorganisation of the cider team it was essential to make a full-time senior appointment in this subject. Dr. Challinor is a graduate of Birmingham University, and since his graduation in 1928 he has been concerned with problems in organic chemistry at Birmingham University under Sir W. N. Haworth, and with problems in biochemistry and bacteriology at the London School of Hygiene and Tropical Medicine with Professor H. Raistrick and the late Professor W. W. C. Topley, and finally in the Department of Bacteriology, Edinburgh University, with Professor T. J. Mackie. Among the subjects previously studied by Dr. Challinor are the constitution of carbohydrate compounds, the antigenic properties of bacteria, the bacteriology of air and the biological preparation of antibiotics, particularly of penicillin and streptomycin. His previous experience thus forms an excellent basis for the work he will undertake on cider.

Mr. S. H. Crowdy was appointed as Assistant Mycologist, to work with Mr. Marsh, who has hitherto been without assistance in his mycological studies on fruit plants. It is now proposed that Mr. Crowdy will give his main attention to specific diseases and their causal organisms, and that Mr. Marsh will concentrate on problems relating to control measures in conjunction with Dr. Martin and Dr. Kearns. Mr. Crowdy graduated from the Imperial College, London, in 1937, and since then has held posts at the Imperial College of Agriculture, Trinidad, as lecturer and advisory officer in Plant Pathology, and later in the Colonial Agricultural Service under the Gold Coast Government in West Africa, where he was mainly engaged in studies on virus and fungus diseases of Cacao.

Dr. W. D. E. Thomas was appointed to the post of Physical Chemist in the Plant Pathology team. This is a new appointment to the permanent staff, although previously temporary appointments have been held for this work under special grants. Dr. Thomas will work in close collaboration with Dr. Martin.

Dr. Thomas graduated from University College, Swansea, in 1936, where he received further specialised training in Physical Chemistry until 1940. Subsequently he was on the scientific staff of the Ministry of Supply, Explosives Research Department, where he was engaged primarily on problems

relating to the sensitivity of explosives. His appointment will make possible more thorough investigation of many problems relating to the efficiency of sprays and dusts applied to fruit trees.

Dr. C. Bould, whose appointment to succeed Mr. J. O. Jones, was recorded in the previous report, took up his appointment in January, 1946.

Other appointments which have been made during the year are as follows :

Mr. C. F. Mills, as Research Assistant in Chemistry under the Agricultural Research Council Mineral Deficiencies Scheme from 1st February, 1946.

Mr. E. W. Jones, as Research Assistant in Plant Physiology, under the Agricultural Research Council Mineral Deficiencies Scheme, from 18th November, 1946.

Mr. N. G. Morgan, as Research Assistant in Entomology, from 8th March, 1946.

Mr. D. G. Whiteford, as Research Assistant in Chemistry, from 1st January, 1946.

The following resignations were received :—

Dr. W. E. Berry, Plant Physiologist, on appointment in the Ministry of Supply, with effect from 1st January, 1946.

Dr. E. H. Wilkinson, Research Assistant in Mycology, under the special grant of the Agricultural Research Council for research on Diseases of Hops, on appointment to a commercial post from 31st October, 1946.

Mr. V. E. Sills, Chemist in Cider Section, on appointment to a commercial post from 31st March, 1946.

Mr. D. G. Whiteford, as Research Assistant in Chemistry, from 30th September, 1946.

We are happy to record the safe return of Mr. D. H. Pittman, Senior Clerk, in May, from service in the R.A.F. Mr. Pittman joined the service in 1940 and was subsequently engaged abroad on flying duties in Coastal and Transport Commands, attaining the rank of Warrant Officer. Miss V. E. R. Alsop also returned from service in the A.T.S. in November, having served from June 1943 to September 1946.

During the year Dr. Martin and Miss Crang visited Germany under schemes sponsored by the Ministry of Agriculture, the necessary arrangements being made by the British Intelligence Objectives Sub-Committee (B.I.O.S.) of the Control Commission for Germany. In both instances the visits were extended to centres of interest in Switzerland.

Dr. Martin's visit was made in May and he was accompanied by Dr. H. Shaw, East Malling. Their objectives were to investigate developments made in pest control materials and methods in Germany during the war years and to renew contacts with workers in Swiss research stations.

Miss Crang's visit was made during September and she had as her colleague Miss M. Mason, of the Ministry of Agriculture. Their special objectives were to examine the extent to which domestic preservation methods had been used and developed in Germany during the war and to investigate the progress made in these methods in Switzerland.

Both visits proved fruitful of results and reports have been drawn up for future circulation after classification by B.I.O.S.

Buildings and Land.

Although it was not possible to erect any new buildings or to enlarge any of the old ones during the year, it was possible to proceed with some urgent painting work on greenhouses and with some alterations in the main laboratory

building. A contract was made for the painting of all the greenhouses, including the pot culture house, during the late summer and autumn of 1946, but owing to the excessively wet weather which continued without a break until the end of the year, it was impossible to carry out the work promptly. A certain amount of the work on the pot culture house was spoilt by frost following a wet period and will need to be repeated in 1947.

The re-fitting of the laboratories vacated by the advisory officers has already been mentioned. In addition the library was redecorated and some laboratories were colour-washed. The remainder of the rooms in the main building are also in urgent need of internal decoration and in many of them the flaking of colour wash from ceilings and walls is liable to interfere with the laboratory work. Up to the present it has not been possible to arrange for the external painting of any of the Station property and unless this is undertaken in the near future serious deterioration will result.

During the year the new advisory building at Evesham was completed for the Ministry of Agriculture, and this freed the wooden building, previously used, for other purposes. This hut is the property of the Agricultural Research Council and was lent to the Station for advisory work during the war period. By arrangement with the Council and the Ministry of Agriculture it was removed to Long Ashton at the end of 1946 and erected on the north side of the road in front of the workshops for the use of members of the Pathology team.

On the closing down of the Station work at Evesham, letters of thanks were sent to the Rudge Estate, the landlords of the Abbey Road site on which the hut had stood, and to the Borough Council of Evesham, who had given permission to erect and maintain the hut during the war period. Special thanks are due to Messrs. Byrd, tenants of the site, for the many ways in which they have helped and in particular for restoring the site after the removal of the hut.

A beginning was made with the suggested programme of road repairs, the tar-macadam surface on the road between the cider house and the main laboratory building being completed. The boundary fence on the north side of the fruit plantations, extending from Keeds Lane to the Director's House, which was in a dilapidated condition, has been replaced by a stout wire fence supported on concrete posts.

The position regarding living accommodation for new members of staff remains difficult, although we have been fortunate in obtaining the assistance of the Long Ashton Rural District Council, to whom best thanks are due, in placing three members of staff in houses on the new housing estate at Tyntesfield. Some urgent cases, however, still remain.

Mr. J. H. Butler has continued his tenancy of the outlying portions of the farm.

In the fruit plantations no new plots were established during the year. Nursery work, however, is being pressed forward as rapidly as possible. Stocks for tree fruits of various kinds are being multiplied and material is being prepared for two large trials of plums.

The willow plots are being extended with the aim of forming as complete a collection as possible of willow species and varieties. During the winter of 1945-46 some 200 willow varieties were set out on $1\frac{1}{2}$ acres of newly-prepared land at a planting distance of 3 x 3 feet to enable full advantage to be taken of mechanical cultivation.

With the departure of Dr. Wilkinson, who was in charge of the small

experimental plots of Hops at the Station, changes are proposed under the Agricultural Research Council Scheme, and it is likely that the plots will not be required after 1947.

On the bush cider plot a comprehensive series of trials was begun, including comparisons of cultural systems and manurial treatments. The cultural systems comprise clean cultivation, annual cover crops to be ploughed in, permanent covers of grass, and of grass and clover mixtures. The manurial treatments include deficiencies of nitrogen, phosphorus and potassium and are superimposed on a grass and clover sward. The experiments are designed to provide information on the effects of cultural systems and manures on the growth and mineral status of the trees and the quality of the fruit, and on the maintenance of soil fertility.

1946 was also the first year of cropping on the black currant manurial plots where comparisons are being made between various organic materials, particularly sewage sludge, and composts made from straw with sewage sludge and town refuse, and inorganic fertilisers. It is of interest that in this first season, whilst sewage sludge used alone has given good results, the composted materials have substantially reduced the nitrogen status of the plants.

1946 was a difficult year for work on the farm due to the very wet and stormy conditions which prevailed throughout the active growing season and during the autumn. Harvesting operations, in particular, were difficult, and it was only possible to gather in the cider fruit crop with the help of unskilled labour from outside.

Research Activities.

In the investigations on mineral deficiencies of crops, surveys of deficiencies, using a sampling method, were completed for the counties of Hereford and Somerset. The results show that the method can be used to obtain a general picture of the status of crops for nitrogen, phosphorus and potassium over areas of county size in the course of a season.

Good progress was again made in pot culture work. Further surveys of deficiency symptoms for a number of crops were made, special attention being given to boron deficiency. In experiments on the soil acidity complex further relationships between acidity (pH), calcium deficiency and manganese toxicity were demonstrated. It was shown with celery that, whilst sodium greatly increases growth, it may be very damaging if either calcium or potassium is low, particularly calcium, the growing point being killed. In investigations on technique excellent results have been obtained in demineralising tap and rain water by means of a Permutit unit. For sand purification an automatic steam-operated washing plant has been successfully used. It has been shown that bitumen paint provides a satisfactory coating for the insides of clay pots for use in investigations involving deficiencies of all the major plant nutrients and of boron.

Further improvements in chemical tissue test methods were made as the result of studying the effects of seasonal cycles of mineral nutrients on a number of plants and a new method of testing for deficiency levels of manganese in cereals, using tetramethyldiaminodiphenyl methane, was developed.

In field experiments it was shown that on a strongly acid soil the mineral deficiencies which affect a crop such as potatoes are largely dependent on the manurial treatment given. In diagnosing field deficiencies close agreement has been obtained between visual and chemical methods. Further experiments on magnesium deficiency of tomatoes in greenhouses has shown that the

2 per cent. magnesium sulphate spray previously recommended can be combined with a fungicide, such as Shirilan, when *Cladosporium* is also a problem.

On the experimental vegetable plots at the Station the abnormally heavy rainfall resulted in acute deficiencies of nitrogen and magnesium in cauliflowers. In these trials compost and stable manure treatments were associated with exceptionally low nitrogen status, which greatly delayed the formation of the curds.

In the apple manurial experiments comparisons between the treatments N P K and N show that the former treatment, whilst giving more vigorous growth and larger fruits, is resulting in magnesium deficiency which may eventually greatly reduce vigour. The "N only" trees show a low potash status.

A memoir on the land classification map of Gloucestershire, Somerset and Wiltshire has been prepared and will shortly be published by the Bristol University Reconstruction and Research Group. It gives a good general picture of the distribution of land categories in the three counties.

In the further progress of the work on growth promoting substances in relation to fruit setting and development, a point which may prove of considerable importance emerged. Attempts were made to extract hormones from apple pomace and from blossoms and young fruits of apple, pear and plum, but without success. Extracts obtained from young apple seeds, however, were active in stimulating and developing unfertilised tomato ovaries. The potency of the extracts of seeds from Crawley Beauty decreased gradually with age and disappeared ten weeks after petal fall. Potency appeared to be related to the rate of growth of the seed and with the content of the glucoside phloridzin. The result thus suggests that effective growth promoting substances for the apple may be related to this compound, a point which it is planned to investigate further in 1947.

The pear Bristol Cross continues to show heavy cropping qualities and appears to be a useful commercial sort. Of the new black currant varieties, Mendip Cross and Cotswold Cross are finding a place in commercial plantings and it now seems likely that a third variety, Malvern Cross, which is later than Cotswold Cross, will prove a valuable addition. Several of the newer apples, pears and plums also appear promising, among which may be mentioned a late, dark blue culinary plum, with a slight damson flavour, which has been named Frome Cross.

In Pathology the programme of joint work on laboratory and field assays of insecticides and fungicides has been extended. A laboratory technique has been developed for determining mortality curves for D.D.T.-oil films, using *Calandra granaria* as the test insect, and the comparative study of insecticidal products of the D.D.T. series has been continued. In field trials it was found that *Aphis pomi* was controlled by D.D.T. applied at the green cluster stage provided that thoroughness of spraying and exposure of the insects permitted effective contact. Observations were maintained on the residual effects of D.D.T. on the fauna of fruit trees.

In tests with certain organic thiocyanates as ovicides, dodecyl thiocyanate was found to be effective against eggs of apple sucker and red spider.

Dinitro-cresol at 0.1 per cent. proved equally effective whether present as cresol or the cresylate against eggs of apple sucker or winter moth, but the cresol was more ovicidal against eggs of red spider. The decomposition of dinitro-cresol which may occur in corroded containers yields reduction products without effect on the eggs of apple sucker, red spider or winter moth. Both

tar oil and DNC washes applied to the soil under currant bushes greatly reduce initial infestation by currant midge but the residual population rapidly increases.

Bio-assays of organic fungicides against apple scab and black currant leaf spot have continued. Ferric dimethyldithiocarbamate (Fermate) was shown to be effective against the leaf spot disease and is not objectionable in processed currants if the fruit is first heated. Soil treatments against *Armillaria mellea* are under investigation.

Specifications for spraying machinery and equipment have been published and a machine designed at Long Ashton is now in production for the Ministry of Agriculture Supplies Division. A detailed study of (1) manual operation of spray lances (2) fully automatic spraying, is in progress. A multi-purpose unit applicable for dusting, fumigation or atomization was constructed in the winter of 1946.

In the cider section the main practical interest at present concerns the trial of bush cider trees. It has been shown that with this type of tree heavy crops, similar in weight to those obtained from culinary and dessert varieties, can be obtained after 8 to 10 years from planting and that ciders of high quality can be made from the fruit. These results are of great importance at the present time since a serious shortage of cider fruit is threatened in the near future. The method has certain drawbacks for cider fruit production, but it seems at least to provide a means of greatly increasing supplies during the course of the next few years.

In view of the serious orcharding problems there is an urgent need for investigations of cider pomology and an active beginning has been made in this subject. The work is proceeding along two main lines: the collection, description and photographic recording of cider fruits; and the surveying of cider orchards.

The main work on fruit products has been concerned with problems of ascorbic acid retention in fruit juices, particularly in black currant and apple juices, and with the content of ascorbic acid in English apple varieties. In the latter connection it has been shown that many apple varieties contain considerable amounts of ascorbic acid, the range for culinary and dessert sorts examined in 1946 being 7 to 22 mg. per 100 gm. and for cider sorts 7 to 39 mg. per 100 gm. It is of special interest that the cider variety giving the high value of 39 mg. per 100 gm. is the heavy cropper Yarlington Mill.

In a further examination of the problem of blackening of potatoes a fraction has been isolated from tubers susceptible to the trouble which when brought into contact with ferrous iron produces the typical blackening effect.

During 1946 hop investigations were extended to include a survey of insects infesting hop yards, as a basis for examining possible vectors of virus diseases, and soil and nutritional surveys were made in an attempt to establish relationships between the incidence of nettlehead and the nutritional status of the hop plants. The entomological survey established the presence of several pests of hops, including the hop flea beetle (*Psylliodes attenuata*), the hop damson aphid (*Phorodon humuli*), the aphid *Macrosiphum gei*, *Thrips fuscipennis* and the green capsid (*Lygus pabulinus*). In the soil investigations no correlations were apparent between the main soil types and the mineral status of the plants and the incidence of nettlehead.

Annual Field Day. The Annual Field Day for members was held on Friday, July 5th, in combination with the Annual Meetings of the Governors and Members of the National Fruit and Cider Institute. Members were able

to see much of practical interest during the day in the form of extensive exhibits in the laboratories, and in the pot culture enclosure and plantations.

Cider Sampling Day. As it has not been found possible to resume the Cider Tasting Day function in its pre-war form, arrangements were made in 1946 to hold a Cider Sampling Day to which members with special interests were invited to inspect the season's ciders and to discuss current problems.

A special demonstration was given by Professor Barker and members of the cider staff on "The Vintage Quality of Cider Apples in relation to the influence of Site, Season and Rootstock," the ciders used being the produce of the bush trees from the various trial centres. It is proposed to hold a similar day in 1947 when another topical subject will be demonstrated.

Visitors. Organised parties in 1946 numbered 54 and included a group of senior American scientists whose reception at Long Ashton was the subject of a letter of appreciation from the Permanent Secretary of the Ministry of Agriculture. Other parties calling for special mention were: delegates from the French Ministry of Agriculture, Agricultural Education Association, Advisory Chemists' Conference, Advisory Mycologists' Conference, and the South-Western branch of the Horticultural Education Association. The full list is as follows:—

Advisory Chemists' Conference.
 Advisory Mycologists' Conference.
 Agricultural Education Association.
 Almondsbury Home Food Production Club.
 American Senior Agricultural Scientists.
 Backwell and District Horticultural Society.
 Berkeley Square Advisory Centre.
 Bristol Naturalists: Botanical Section.
 Bristol University Microbiology Students.
 British Association of Chemists and Association of Scientific Workers.
 Cheltenham Grammar School.
 Clifton High School.
 Dominion Students.
 Dorset W.A.E.C.
 Downend Home Food Production Club.
 European Newspapermen.
 Evesham Growers.
 Featherstone (Middx.) Secondary Boys' School.
 Filton Horticultural Society.
 Fishponds Diocesan Training College.
 French Ministry of Agriculture Delegates.
 Gardenhurst School, Burnham.
 Gloucester Training College of Domestic Science.
 Gloucestershire Home Food Production Society.
 Henstridge R.N. Air Station Agricultural Course.
 Hereford County Produce Committee.
 Herefordshire N.F.U. Horticultural Branch.
 Horticultural Education Association, S.W. Branch (2).
 Long Ashton Members' Meeting.
 Ministry of Agriculture Inspectors.
 Monmouthshire Agricultural Institute.
 Monmouthshire Produce Guild.
 N.P.K. Club.
 National Association of Corn and Agricultural Merchants.
 National Association of Willow Growers.
 National Smelting Company Scientific Club.
 National Union of Students.
 Newent N.F.U. Horticultural Branch.
 Newport and County Horticultural Society.
 Nosey Parker Group, Shirehampton.
 Okehampton and District N.F.U.
 Reading University Students.
 Sea Mills Townswomen's Guild.
 Sherborne Allotments and Gardens Association.
 St. Annes' Men's Contact Club.

Stowey and Bishop's Sutton Women's Institute.
 Studley Horticultural College.
 Taunton and District Gardeners' Association.
 Wimborne St. Giles Gardens and Allotments Association.
 Worcestershire Teachers.
 Wroughton Gardeners' Society.
 Wye College.
 Yeovil and District Young Farmers' Club.

The year also saw a general resumption of visits from overseas scientists among whom were Sir Theodore Rigg (Director of the Cawthron Institute, New Zealand), Dr. E. S. Archibald (Director of Dominion Experimental Farms, Canada), Mr. M. B. Davis (Dominion Horticulturist) and Dr. J. H. Craigie (Dominion Botanist), Canada, and Mr. Maya-Das (Director of Agriculture, United Provinces, India). Other countries represented by individual visitors were Argentina, Australia, Costa Rica, Dutch East Indies, Egypt, Holland, Kenya, Malay, Sweden, Turkey and U.S.A.

Shows and Demonstrations. Lectures, talks, demonstrations and the staging of educational exhibits were continued in 1946 on the same scale as in the previous year, but it is anticipated that much of this work in future will be undertaken by the National Agricultural Advisory Service. An outstanding exhibit, covering all sections of the Station's activities, was staged for the Bristol Farm Week (August 14-24). The full list of shows and demonstrations is as under :—

Advisory Mycologists' Conference. Pests and diseases of crops.
Agricultural Education Association. Ditto.
Bath Autumn Show. New varieties of fruit.
Bishop's Canning Show. Insect pest control.
Bristol Farm Week. Research work at Long Ashton.
Bristol Horticultural Show. New varieties of fruit.
Cheltenham Floral Fete. Tomato diseases.
Cirencester Show. New varieties of fruit.
Evesham Asparagus Show. Asparagus pests and diseases.
Frenchay and Hambrook Show. Vegetable pests and diseases.
Locking R.A.F. Station Demonstration. Vegetable diseases.
Royal Horticultural Society Autumn Show. New varieties of fruit.
Somerset W.A.E.C. Demonstrations (Chedzoy). Clover sickness.

Research Students and Voluntary Workers. Lack of laboratory accommodation still prevents the acceptance of graduates working for higher degrees. Two Polish students from Bristol University were however able to work at the Station during the Long Vacation, namely :—

Mr. Vincent Adamkiewicz, who assisted in the Plant Nutrition section.

Mr. Edgar Eisenbraun, who worked on Organic Chemistry under the direction of Dr. Woodcock.

Instructional courses were continued for officers employed by the W.A.E.C's. on the operation and maintenance of spray machinery.

The arrangements for Home Preservation courses were the same as in 1945, there being three fortnightly courses and two three-day courses in judging preserved produce. A total of 86 students attended, the maximum that could be accommodated. At the request of the Ministry of Food three refresher courses on preservation were arranged for the staffs of Food Advice Centres and held at Long Ashton, Doncaster and Newcastle.

Mr. H. E. Beviss has once more earned the gratitude of the Station by the voluntary help he has given throughout the year in plantations recording.

Acknowledgments. The Institute is again indebted to many growers, industrial firms and other organisations for their continued help and co-operation during the year. Numerous experiments were again carried out in

growers' plantations, and at many of these centres considerable help was afforded in carrying out the work involved. Several firms have again made financial grants towards the work and others have helped by the provision of material for experiments. All these forms of help have contributed to the success attained during the year, and sincere thanks are due to all who have so willingly co-operated.

The special thanks of the Director are due to the scientific staff for their loyal co-operation in the research projects and for the many voluntary services which they have performed to help forward the work of the Station.

Dr. Martin has again rendered valuable assistance with many scientific problems. Dr. Kearns has continued to help in a variety of ways in connexion with buildings, machinery, implements and general farming problems; Mr. Marsh has carried out the main editorial duties and has been responsible for organising the visits of the main parties who visited the Station: Miss Crang and Miss Sturdy have continued to bear the main responsibilities in running the Canteen, and the staff will no doubt wish to join with the Director in expressing thanks to them. Mr. Spinks continued to act as Librarian and has had a particularly busy year re-organising the general arrangements necessitated by the changed conditions arising from the war. Mr. Hobbis, as Plantations Officer, has again had a very difficult year, but succeeded in meeting the many demands made on his services in the carrying out of the field programme.

All other grades of staff have co-operated loyally and willingly during the year, and their interest and work have been much appreciated by the scientific staff. In particular, a special word of thanks is due to the working staffs in the laboratories, office, plantations and cider house, who have all contributed materially to the success of the year's work.

PROGRESS REPORT ON FRUIT BREEDING.

By G. T. SPINKS.

Since the publication of the last report on Fruit Breeding at Long Ashton (1) the work has been seriously interrupted by the war. Owing to the abnormal conditions existing from 1939 to 1945 no new breeding was undertaken, and during those years work was confined to the trial of seedlings which had already been raised, and even this was handicapped, particularly in the case of soft fruits.

The following report gives an account of the position of the work at the present time.

Apples.

Trials of the named seedling varieties have been continued at Long Ashton, at Wisley in the National Fruit Trials and by growers in various parts of the country. Information gained from these trials during the last few years suggests that four of these varieties are not up to the standard required in apples to be grown commercially, as they suffer from one or other of certain disabilities, such as shy bearing, lack of high dessert quality and liability to canker. These varieties, Plymouth Cross, Newport Cross, Hereford Cross and Gloucester Cross, are therefore no longer being definitely recommended though they will still be supplied to anyone wishing to grow them.

Two more varieties still seem worth attention though they have not received particularly favourable notice in the Wisley Trials. Worcester Cross (a cross between Cox and Wealthy) is a good quality dessert apple rather later in season than Worcester Pearmain, but it does not appear to be very prolific and the fruit is apt to be rather too large.

Taunton Cross is about the same season as Worcester Pearmain and, though not as attractive in appearance as that variety, it is considered to be of better quality and has many good points, being a good and regular cropper and resistant to scab. Even before the war, when apples were not in such short supply, several growers found that there was a ready market for it.

About 40 other seedling varieties are still on trial, and are the surviving representatives of a considerable number of different crosses. Some of these have been cropping well for several years but others have not yet borne appreciable crops as they were only selected and propagated at the beginning of the war.

Several early dessert varieties are among the selections. They are all the results of a cross between Worcester Pearmain and Beauty of Bath, and are of fairly good quality and attractive appearance but not quite as early as Beauty of Bath. To follow these there are two varieties, obtained from Allington Pippin x Star of Devon, which are very attractive in appearance and in season before Worcester Pearmain. Another sort which is ready at about the same time is a seedling from open-pollinated Beauty of Bath and seems to have distinct possibilities.

Late varieties under trial are the selected progeny of various crosses in which the parents included Cox, American Mother, Sturmer Pippin and Court Pendu Plat. Though the quality of these is known the cropping capacity of most of them has yet to be proved. Many of them have the valuable characteristic of very late blossoming.

Other varieties, which are of various seasons, have not yet had a sufficiently long trial to yield much information about their value. They include a few derived from such parents as McIntosh Red and Delicious, and others obtained from inter-crosses of previously selected seedlings.

All the above-mentioned varieties are suitable for dessert. In addition to these a number of culinary sorts which were selected some time ago are still being grown on a small scale. Several of these are of very good cooking quality and of satisfactory growth and cropping, but at present it is not suggested that any should be named and distributed unless there seems to be a demand for new cooking varieties.

In a new programme of work which has just been started the chief objectives are good early and late dessert varieties, late blossoming being given special consideration. The production of some improved varieties suitable for cider-making is also being attempted.

Pears.

The pear Bristol Cross has now been under trial for a number of years and has been fairly widely distributed. Its record at Long Ashton has been good and favourable reports on it have been received from many growers. Its quality is good, it is a heavy cropper, is resistant to scab and, though very similar to Conference, it is definitely rather earlier in season and can be marketed before that variety is ready.

Another seedling variety has just been named Cheltenham Cross and propagating material is now available to our Members. It is bluntly conical or pyriform in shape, about 4" x 2½" in size, and has a fairly smooth skin of a pale lemon colour, sometimes with a slight flush. The flesh is smooth or slightly crisp, cream in colour, very juicy and sweet and the flavour is very good. The fruit is in season in early or mid-September. The trees are moderate in size, fairly erect in habit with well-spurred shoots. Crops have been good and attacks of scab have been negligible. The parents of this variety were Dr. Jules Guyot and Conference.

Ten other seedling sorts have been under trial for some time, but four of these have just been discarded. The remainder are of various seasons, and while one or two may eventually be found worthy of naming some of the others may have a value as parents for earliness or lateness. In all the above sorts Conference was one parent, the other parent being Durondeau, Dr. Jules, Comice or Williams.

Fifteen years ago three families, consisting of a total number of about 250 seedlings, were raised and were planted out to grow on their own roots. The parentage of the families was (i) Bristol Cross x Comice, (ii) Bristol Cross x a late season seedling, W.Ce.5, (iii) W.Ce.5 x Comice. From time to time useless seedlings were discarded, but some of the original trees are still growing and these include 13 which have been propagated for further trial. These are of various seasons, some of them being late-keeping sorts. Of the remaining original trees there are a few more which may yet be found worthy of propagation.

New families are now being raised with the object of obtaining late varieties, some of the best late seedling sorts being crossed with Comice.

Plums.

Four new varieties were named some years ago and have been distributed, though not very widely. Wye Cross, a late blue cooking plum of good quality,

is reported to be susceptible to Bacterial Canker at Wisley and is often attacked by Silver Leaf at Long Ashton. Avon Cross, a late dessert plum of very good quality under favourable conditions, is also said to suffer from Bacterial Canker, and at Long Ashton it is always badly attacked by Brown Rot. It rather appears that both these varieties are too susceptible to diseases and will not be of much value. Teme Cross, an attractive good quality dessert plum, in season in late August, has been more satisfactory, though rather susceptible to Brown Rot, but has not cropped very well at Long Ashton.

Severn Cross continues to be very satisfactory here, though it is said to suffer from Brown Rot in some places. It is a dessert plum in season in late September, large, golden in colour, very juicy, sweet and of good flavour. It is self-fertile and crops heavily and regularly.

Frome Cross was named in 1946 and distribution has started. This is a good quality cooking plum with a slight damson flavour, in use mid- to late September, dark blue in colour, moderate in size. It is rather similar to Wye Cross but appears to be superior, as the trees are more vigorous and less liable to disease.

Another seedling plum has now been named Thames Cross, and propagating material is available for distribution. It has the same parentage as Severn Cross (Coe's Golden Drop x Giant Prune), and is rather similar to that variety but slightly earlier in season, being ready in the first half of September. The fruit is very large (one plum weighing $3\frac{1}{4}$ oz. was picked in 1946), oval and regular in shape, of a pale golden colour. The flesh is very juicy and sweet and has a good flavour. The trees are vigorous in growth and up to the present they have been free from disease.

About 20 other plums, of various parentages, have been under trial for some time, but it has now been decided that 12 of these have not the qualities required in a new variety and they have been discarded. The remainder will receive a further trial and it is possible that one or two may be suitable for naming.

New crosses are being made aiming at the production of really early dessert varieties.

Black Currants.

It is scarcely necessary to mention Mendip Cross, as this variety is now fairly well-known and is being grown on a considerable scale in various parts of the country. It is included in trials of standard varieties here and continues to be one of the most satisfactory early varieties.

Cotswold Cross, which is the same season as Baldwin, is also proving a good variety, though it does not appear to be as popular as Mendip Cross.

A third variety, Malvern Cross, was named and distributed in 1946. This seems to be a useful variety for extending the season, as it is slightly later than Baldwin: it also has the advantage that the berries are easily detached from the strig. Bushes are vigorous and upright in growth: trusses of moderate length, compact: fruit moderately large, even in size, sweet, skin thick. Good cropper.

Eight more varieties, selected some years ago, are still being tried on a small scale. They are of various origins and differ in their season of use, the earliest being a few days earlier than Boskoop and the latest rather later than Baldwin. Further trial is needed before deciding whether to name any of these.

More seedlings are to be raised, with the objective of a variety late in

season and containing a high content of Vitamin C in the fruit. Such a variety would be of considerable value to manufacturers of concentrated black currant syrups.

Raspberries and Strawberries.

Only a few seedling varieties of these two fruits were being grown in 1939, and since then war-time conditions have made it impossible to carry out any satisfactory trials. It has, however, been possible to eliminate a number of varieties and during the last year trials on a small scale of the few remaining sorts were restarted. These include eight kinds of raspberries and nine strawberries.

SUMMARY.

The progress in fruit breeding work at Long Ashton from 1938 to 1946 is briefly described.

Among the newer seedling varieties now distributed or about to be distributed, the following show special promise :—

Apples	..	..	Taunton Cross.
Pears	..	..	Bristol Cross, Cheltenham Cross.
Plums	..	..	Severn Cross, Frome Cross, Thames Cross.
Blackcurrants	..	..	Mendip Cross, Cotswold Cross, Malvern Cross.

REFERENCE.

- (1) SPINKS, G. T. Progress Report on Fruit Breeding. *Ann. Rpt. Long Ashton Res. Stn.*, 1938, 47.

COVER CROPS IN RELATION TO SOIL FERTILITY AND TREE NUTRITION. AN EXPERIMENT WITH BUSH CIDER TREES.

PROGRESS REPORT I.

By C. BOULD.

Introduction.

It is known in a general way that the manurial requirements of trees under clean cultivation and under cover crops are different, but the effect of cover crops on soil fertility and tree nutrition needs further investigation. This experiment is part of a programme dealing with cover crops and is designed to obtain information on :—

1. The penetration and availability of fertilisers applied to trees under a cover crop of grass plus clover :

2. The effect of different cover crops on the organic matter status, structure, moisture supply and availability of nutrients in the soil :

3. The effect of cover crops on the manurial requirements of trees as determined by their effects on the growth, mineral status, crop yield and fruit quality of bush cider apples. Cider varieties were used because it was the only orchard available for experimental work of this nature.

This report will deal with the layout and management of the experiment, and with data on growth and crop yield during 1946. The work dealing with fruit composition and cider quality is being carried out by the cider section

and will be dealt with separately. Changes in the botanical composition of the cover crops are being investigated by Dr. Luckwill.

Site. Plot 20.

The orchard occupies a total area of approximately $9\frac{1}{2}$ acres, and is situated on the northern side and towards the foot of a ridge of high ground running E. to W. The southern half of the plot (20 A) has a fairly steep S.—N. slope and was chosen for the permanent grass plus clover cover to avoid soil erosion. The northern half of the plot (20 B) is fairly level with a gentle slope from S.—N. and was chosen for the cover crop experiment.

Soil.

Plot 20 A. Grey non-calcareous clay, drainage somewhat impeded. (Series No. 15 as classified by Dr. Osmond, L.A.R.S. Annual Report 1936.)

Plot 20 B. Reddish brown non-calcareous heavy sand, drainage slightly impeded. (Series No. 6.)

Surface soil samples, 0–9", were taken from plot 20 A, and samples at 0–6", 6–12" and 12–24" from plot 20 B, on a sub-plot basis. It is proposed to carry out detailed chemical analyses on these samples.

Apple Varieties and Previous History.

The orchard was planted in 1935 to investigate the production of cider apples on bush trees. Four varieties were chosen, namely: Knotted Kernel, Sweet Alford, Stoke Red and Dabinett. At the commencement of the cover crop experiment it was found that the variety Knotted Kernel contained quite a number of rogues of the variety Woodbine, so that it has been excluded from the experimental results. Each variety is worked on both Crab and Mallington I rootstocks.

From 1935 to 1944 the orchard was under clean cultivation and was intercropped with blackcurrants and trees on type IX rootstock. The intercrops were removed in 1944. (For details see L.A.R.S. Annual Reports for 1941 and 1942.) Trees now stand at 20' x 20'.

Layout of the Experiment.

The layout is shown in Fig. 1.

The trees are planted in rows running N. to S., each row consisting of one variety on alternating rootstocks. Trees are numbered from N. to S., odd numbers consisting of trees on Crab and even numbers of trees on Mallington I. From W. to E. the varieties are planted in the order, Sweet Alford, Dabinett, Knotted Kernel and Stoke Red, except in the centre where the varieties Dabinett and Knotted Kernel are separated by two rows of Laxton's Superb. The rows are numbered from W. to E. starting with row number 2.

Plot 20 A.

The area is divided into four blocks, each block containing five plots, and each plot (with the exception of the centre plots) twenty-four trees, six trees (three on Crab and three on Mallington I) each of four varieties. Area of each plot = 0.22 acre.

The whole area was seeded on 2/5/46 with the following mixture:—

S.23 Perennial Rye Grass	20 lbs.	} per acre
S.100 White Clover	2 lbs.	

Germination was good. First cutting took place on 27/6/46 and six further cuttings were given with a "gang mower" between this date and 11/11/46. All grass cuttings were left *in situ*. No fertilizers were applied during 1946, but the following treatments will be given during 1947 :-

A = N.P.K.	
B = N.P.	
C = N.K.	
D = N.	
E = No Manure.	
N = 3 cwt. nitro-chalk	} per acre
P = 3 cwt. superphosphate	
K = 1 cwt. muriate of potash	

These rates are only tentative and will be changed according to the response of the trees.

Treatments A to D are randomized within the blocks, but treatment E, being considered the least important, was localised in the centre of the orchard where the plots consist of two varieties only in duplicate. The layout of this experiment, as in plot 20 B, was compromised by the existing arrangement of the varieties.

Plot 20 B.

This area is divided into two blocks, each block containing five plots and each plot (with the exception of the two centre plots) 48 trees, 12 trees each of four varieties (six on crab and six on Malling I stocks). Each plot receives a single treatment.

Treatments.

During 1946 the plots received the following treatments :—

- A. Perennial rye grass.
- B. White clover S 100.
- C. Annual cover crops. Vetch followed by rape and winter rye.
- D. Clean cultivation.
- E. Perennial rye plus clover.

Management.

A. Sown with perennial rye grass S 23 at the rate of 20 lbs. per acre on 7/5/46. Germination good. First cutting on 27/6/46 and six further cuttings with a gang mower between this date and 11/1/46. All grass cuttings were left *in situ*.

B. Sown with white clover, S 100 on 7/5/46 at the rate of 4 lbs. per acre. Germination good. Cuttings, same as for treatment A. Only a few flowers formed during 1946.

C. Vetches were sown on 7/5/46 at the rate of 1 cwt. per acre. Germination and growth were good. When the plants were in flower (22/7/46) they were rolled, and then disced into the surface soil. Further discing and harrowing was given a few days later, but this failed to cover all the plants. Rape was sown on 27/7/46 at the rate of 30 lbs. per acre. Germination was good but growth was poor, the plants showing symptoms of nitrogen deficiency. The rape was disced into the soil on 12/9/46. Winter rye was sown on 27/9/46 at the rate of 2 cwt. per acre. Germination was rather thin. Samples of vetch and rape were taken for analysis prior to discing in.

KEY TO COVER CROP EXPERIMENT.

Varieties :—

R = Stoke Red
 K = Knotted Kernel
 D = Dabinett
 A = Sweet Alford
 S = Laxton's Superb

Rootstocks :—

O = Crab
 X = Malling Type I

Treatments :—

Plot 20 A.

A N P K	} Grass + Clover Cover
B N P	
C N K	
D N	
E No Manure	

Plot 20 B.

A Perennial Rye Grass
 B White Clover S. 100
 C Annual Cover Crops
 D Clean Cultivation
 E Perennial Rye + Clover

S1 to S30

= Soil Sample Numbers

D. Arable plots were cultivated at frequent intervals corresponding roughly with the time of grass mowing. No further cultivation was given after the last mowing and weeds were allowed to establish during the winter.

E. The same rye plus clover mixture was used as for plot 20 A. Management was the same as for treatments A and B. In no treatment was any material removed from the plots, with the exception of the small samples of rape and vetch used for chemical analysis. Time of cutting was determined by weather conditions and height of cover. When using a "gang mower" the herbage should not get too long. Cuttings were made between and across the rows.

Spray Programme.

The same treatment was given to all plots and consisted of a winter wash and two lime sulphur sprays.

Results. 1946.

Certain trees have been replanted since 1935 and others appear abnormal. The data from these trees have not been included in the yields, etc., and in order to make the results comparable they have been expressed as the mean value per tree per plot.

Blossom Density.

Assessment was made of blossom density on a tree basis using seven categories. These categories were given points and a summary of the results is given in Table I.

TABLE I.
BLOSSOM DENSITY. MEAN VALUE PER TREE FOR 1946.
PLOTS 20 A AND B.

Rootstock	* Sweet Alford (209)		* Dabinett (206)		* Stoke Red (200)	
	20 A	20 B	20 A	20 B	20 A	20 B
Crab Short Leg ..	2.1	1.7	5.0	5.0	3.7	3.6
Long Leg ..	2.1	1.9	5.0	5.3	3.6	4.3
Malling I Short Leg ..	3.3	2.5	5.0	5.0	3.8	4.4
Long Leg ..	3.4	2.8	5.0	5.0	4.2	4.6
General Category ..	Light-Medium		Medium-Heavy		Medium	

* Number of recorded trees.

Rootstock effect on blossom density was not very marked except with the variety Sweet Alford, trees on Malling type I carrying a heavier blossom than trees on Crab.

Yield of Fruit.

The fruit was harvested on the following dates :—

Stoke Red 10—22/10/46.

Sweet Alford 22—26/10/46.

Dabinett 28/10—5/11/46.

Weights were recorded on a tree basis. The results from plot 20 B are given in Tables II, III and IV.

TABLE II.
AVERAGE WEIGHT OF FRUIT IN LBS. PER TREE.
PLOT 20 B 1946.

Treatment			Variety						Total
			Stoke Red		Sweet Alford		Dabinett		
			Crab	M 1	Crab	M 1	Crab	M 1	
Perennial Rye ..	A 1	159.7	129.2	24.8	41.0	176.5	96.5	1,289.5	
	A 2	131.2	156.7	23.2	25.2	184.8	140.8		
White Clover ..	B 1	88.4	81.6	12.8	20.0	109.2	54.7	944.5	
	B 2	115.4	183.2	7.2	31.5	134.5	106.0		
Annual Cover Crops	C 1	208.0	196.7	9.8	17.3	100.3	79.0	1,151.0	
	C 2	204.3	195.2	8.2	11.0	86.4	34.8		
Clean Cultivation ..	D 1	56.0	57.2	8.7	12.2	59.5	25.7	837.6	
	D 2	175.8	176.0	12.5	44.5	128.2	81.3		
Total ..		1,138.8	1,175.8	107.2	202.7	979.4	618.8		

The analysis of variance showed that differences due to blocks, treatments and varieties were significant at 1% level of P. Stock effects were significant at 5% level of P. The first order interactions blocks x treatments, blocks x varieties, treatment x varieties and varieties x stocks were also significant at 1% level of P.

TABLE III.
EFFECT OF TREATMENTS ON YIELD OF FRUIT.
WT. OF FRUIT IN LBS. FROM THE SUM OF 12 MEANS.
PLOT 20 B 1946.

A Perennial Rye Grass	B White Clover	C Annual Cover Crop	D Clean Cultivation	S.E.	Sig. Dif. 5% P	Sig. Dif. 1% P
1,289.5 (1)	944.5 (3)	1,151.0 (2)	837.6 (4)	44.9	132.0	179.5

For 1% level of P. $A > B, D$; $C > B, D$.
For 5% level of P. $A > B, C, D$; $C > B, D$.

TABLE IV.
EFFECT OF ROOTSTOCK ON YIELD OF FRUIT.
WT. OF FRUIT IN LBS. FROM THE SUM OF 8 MEANS.
PLOT 20 B 1946.

Variety			Stock		S.E.	Sig. Dif. 5% P	Sig. Dif. 1% P
			Crab	Malling I			
Stoke Red	..	..	1,138.8	1,175.8			
Sweet Alford	..	..	107.2	202.7	36.7	111.6	155.0
Dabinett	..	..	979.4	618.8			

Rootstock effect was significant on Dabinett, approached significance on Sweet Alford, but was not significant on Stoke Red.

Although plot 20 A received no fertilizer treatments the fruit yield was recorded on a tree basis, and the results analysed as for a uniformity trial. The analysis of variance indicated a highly significant variation between plots. The standard error of the mean weight per tree per plot was ± 26.4 lbs. The general effect of rootstock on crop weight was not significant, although the differences were similar to those shown on plot 20 B. The interaction between rootstocks and variety was highly significant. The results are shown in Table V.

TABLE V.
EFFECT OF ROOTSTOCK ON YIELD OF FRUIT. WT. OF FRUIT IN LBS. FROM THE SUM OF 16 MEANS.

Variety	Rootstock		S.E.
	Crab	Malling I	
Stoke Red	1,768.4	1,711.1	105.8
Sweet Alford	701.3	1,187.2	
Dabinett	1,672.5	1,424.8	

The total yield of fruit from the two plots, 20 A plus 20 B, is given below:—

		Tons.	Cwts.	Lbs.
Stoke Red	=	11	3	47
Sweet Alford	=	3	13	81
Dabinett	=	9	4	51
{ Knotted Kernel	=		12	85
{ Woodbine	=		4	89
		24	19	17

Deficiency Symptoms.

Stoke Red. Row 5—Low nitrogen and a trace of iron deficiency.
Row 9—Low nitrogen in centre trees.
Row 23—Low nitrogen and possibly potassium.
Rows 31 and 35—Low nitrogen and some potash scorch.

Sweet Alford.

General manganese deficiency symptoms with some suspected magnesium deficiency.

Dabinett. Row 3. Potash scorch general with some manganese and iron deficiency.
Rows 7, 15, 19, 29, 33, 37. Potash scorch fairly general, more severe on small trees. Some iron deficiency but very localised.
Row 25. Potash scorch fairly severe on small trees. Tissue tests gave values from M—to Low for affected trees.

During 1947 it is proposed to carry out detailed chemical analysis of the leaves so as to correlate symptoms with mineral status.

Acknowledgments.

The author wishes to express his thanks to Mr. Jarrett, who was responsible for the care of the trees and the taking of records.

Thanks are also due to Mr. Hobbs for help and advice on management.

Summary.

1. The layout, management and aims of a field experiment dealing with cover crops in relation to soil fertility and tree nutrition are described.

2. During the first season cover crops and rootstock had a significant effect on yield of fruit.

A MANURIAL EXPERIMENT ON BLACK CURRANTS. PROGRESS REPORT I.

By C. BOULD and E. CATLOW.

INTRODUCTION.

In 1944 a field experiment was laid down to test, over a number of years, the effect of certain organic manures on the growth, yield and chemical composition of black currants. The bulky organic manures are applied on an equal organic matter basis, using stable manure at 10 tons per acre fresh weight as the basic treatment. For comparative purposes an artificial N P K treatment is also included.

This report deals with the layout and management of the experiment together with results for the first two seasons, 1945 and 1946, relating to growth, yield of fruit and chemical composition of the leaves. Samples of fruit were also taken in 1946 by the biochemical section, for quality tests and ascorbic acid determinations, which will be reported on separately.

Site and Soil.

The site used for the experiment is almost level with a gentle slope to North and East. The soil is a brown heavy sand with slightly impeded drainage overlying Keuper Marl. (Series No. 6 of the Research Station soils as classified by Dr. Osmond, L.A.R.S. Annual Report 1936.) Surface samples were taken for chemical analysis in March 1945. The results are given in Table I.

TABLE I.
CHEMICAL ANALYSIS OF SOILS FROM PLOT 7A, AS A PERCENTAGE OF AIR-DRY SOIL.

			N.W.	N.E.	S.W.	S.E.
1% Citric-soluble P_2O_5	..	..	0.027	0.022	0.028	0.025
" " " K_2O	..	..	0.016	0.014	0.018	0.017
Organic carbon	..	..	1.57	1.65	1.52	1.57

Previous to 1918 the site had been under grass for many years, since when cropping has been as follows:—

1918—21. Arable crops.

1922—30. Apples under clean cultivation.

1931—39. " " grass.

1940—44. Market-garden crops.

EXPERIMENTAL AREA AND MATERIALS.

An area of approximately $1\frac{3}{4}$ acres was planted in February 1944 with 2-year-old black currants, one acre with the variety Mendip Cross and $\frac{3}{4}$ acre with Cotswold Cross, both L.A.R.S. stock. The bushes were planted in rows running East to West, 8 ft. between rows and 4 ft. between bushes. Bushes were cut to ground level after planting.

The manurial treatment of the two varieties differs, so the layout and results for each variety are described separately.

Experiment I: var. Mendip Cross.

This variety receives six experimental manurial treatments, replicated five times. The annual treatments are:—

1. Stable manure—basic treatment at 10 tons per acre.
2. Drained sewage sludge.
3. Straw-sewage sludge compost.
4. Straw-nitro-chalk compost.
5. Inorganic fertilizer. Nitro-chalk + superphosphate.
6. Nil.

In addition to the above treatments all plots receive a dressing of potassium chloride at the rate of 2 cwts. per acre per annum. Treatments 2, 3 and 4 are varied so as to supply an amount of organic matter equivalent to that of treatment 1. In treatment 5 nitro-chalk is applied at the rate of 6 cwts. per acre, and superphosphate at such a rate as to give an amount of P_2O_5 equivalent to that of treatment 4 in experiment II.

The bulky organics are applied broadcast over the whole area in February–March, followed by shallow ploughing. The inorganics are applied after ploughing.

Layout. The plots are arranged in five randomized blocks, each block containing six plots. Each plot contains twenty-one recorded bushes and is bounded N–S. by one buffer row and E–W. by three buffer rows (to minimise drag effect during cultivation). The area of each plot for purposes of manuring is $1/42$ acre. Total experimental area including buffer rows = 0.964 acre.

Experiment II: var. Cotswold Cross.

This variety receives six manurial treatments, replicated four times. The treatments are:—

1. Stable manure—basic treatment at 10 tons per acre.
2. Drained sewage sludge.
3. Sewage screenings—town refuse compost.
4. Meat and bone meal.
5. Inorganic fertilizer. Nitro-chalk + superphosphate.
6. Nil.

In addition all plots receive an annual dressing of potassium chloride at the rate of 2 cwts. per acre. Organics are applied on an equal organic matter basis. Meat and bone meal is used so as to give a nitrogen dressing equivalent to 6 cwts. of nitro-chalk per acre. This treatment supplies in an organic form the same amount of total nitrogen and total P_2O_5 as treatment 5 in experiment I. Time and method of application are the same as in experiment I.

Layout. The plots are arranged in four randomized blocks, each block containing six plots and each plot twenty-one recorded bushes. Size of plot and arrangement of buffer rows are the same as in experiment I. Total area including buffer rows = 0.776 acre.

RESULTS : SEASONS 1945, 1946.

Experiment I: var. Mendip Cross.

Vigour: 1945. Growth was generally good with no differences due to treatment. Foliage was dark green.

1946. Growth was good but differences due to treatment were beginning to show. The order of vigour by observation and allocation of points was: drained sludge > N P > stable manure > straw-nitro-chalk compost > nil > straw-sewage sludge compost. Bushes on N P and drained sewage sludge plots had dark green foliage. On plots receiving composts and stable manure, leaves were pale to medium green. On plots receiving nil, leaves were pale green with marked red tinting later in the season.

Pruning Weights: 1945. There were no significant differences due to treatment.

1946. Differences due to treatment were highly significant. The results are given in Table II.

TABLE II.
PRUNING WEIGHTS IN LBS. MEAN WEIGHT PER BUSH: VAR. MENDIP CROSS.

	Treatments						S.E. Mean	Differences
	1 Stable Manure	2 Drained Sludge	3 Straw- Sludge Compost	4 Straw- Nitro- Chalk Compost	5 N P	6 Nil		
Year								
1945	1.26	1.31	1.41	1.36	1.38	1.24	0.1205	Not significant
1946	1.91	2.31	1.41	1.62	2.00	1.23	0.1604	Sig: at 1% level P
Order	(3)	(1)	(5)	(4)	(2)	(6)		

The significant difference at 1% level of *P* was 0.645 lb.

Treatment, 2 > 4, 3 and 6: 1 and 5 > 6.

It will be seen that the pruning weights for 1946 confirm the order of vigour as determined by observation, with the exception of treatments 3 and 6. The results indicate that the nitrogen in drained sludge is fairly readily available, but that in the composts is much less so.

Yield of Fruit: 1945. The first crop, potentially small, was largely destroyed by frost. Differences due to treatments were not significant.

1946. The crop was good. Differences due to treatment were not significant. The results are given in Table III. Owing to the small yield in 1945, the weights are given on a plot basis, but those for 1946 are expressed as the mean weight per bush.

TABLE III.
YIELD OF FRUIT FROM VAR. MENDIP CROSS, 1945: MEAN WEIGHT IN LBS. PER PLOT.
1946: MEAN WEIGHT IN LBS. PER BUSH.

	Treatments						S.E. Mean	Differences
	1 Stable Manure	2 Drained Sludge	3 Straw- Sludge Compost	4 Straw- Nitro- Chalk Compost	5 N. P	6 Nil		
Year								
1945	7.35	7.20	6.80	7.65	6.80	7.00	0.790	Not significant
1946	3.77	3.75	2.80	3.28	3.47	2.96	0.442	Not significant
Order	(1)	(2)	(6)	(4)	(3)	(5)		

Leaf Analysis: Mature leaf samples were taken from current growth on 24.6.46, on which nitrogen determinations were made. The results are given in Table IV.

TABLE IV.
EFFECT OF MANURIAL TREATMENTS ON THE NITROGEN CONTENT OF BLACK CURRANT LEAVES, VAR. MENDIP CROSS. NITROGEN AS A PERCENTAGE OF DRY MATTER (MEAN OF 5 PLOTS).

	Treatments						S.E. Mean	Differences
	1 Stable Manure	2 Drained Sludge	3 Straw- Sludge Compost	4 Straw- Nitro- Chalk Compost	5 N P	6 Nil		
Total N	2.564	2.780	2.568	2.564	2.910	2.552	0.0355	Significant at 1% level P
Order	(4)	(2)	(3)	(4)	(1)	(6)		

The significant difference at 1% level was 0.1428.

Treatments 2, 5 > 1, 3, 4 and 6.

The significant difference at 5% level was 0.1047.

Treatments 5 > 1, 2, 3, 4 and 6; 2 > 1, 3, 4 and 6.

Leaf analysis for total nitrogen shows that N P and sewage sludge treatments have increased the nitrogen content whereas composts and stable manure have not.

Experiment II: var. Cotswold Cross.

Vigour: 1945. Growth was good, with only small differences due to treatments. Bushes receiving stable manure, town refuse compost and nil were slightly less vigorous and showed foliage paler green than bushes receiving other treatments.

1946. Growth was generally good. The order of vigour as determined by observation and allocation of points was: N P > drained sludge and meat and bone meal > stable manure > town refuse > nil. Foliage was dark green on bushes receiving treatments 2, 4 and 5; medium—dark on treatments 1 and 3; and pale—medium on treatment 6.

Pruning Weights: 1945. No significant differences due to treatments were recorded.

1946. Differences due to treatments were significant at 5% level of *P*. The results are given in Table V. They show that the nitrogen in meat and bone meal is readily available and has been equally effective as an equivalent amount of nitro-chalk nitrogen. The nitrogen in stable manure and town refuse compost does not appear to be as available as the nitrogen in sewage sludge.

TABLE V.
PRUNING WEIGHTS IN LBS. MEAN WEIGHT PER BUSH, VAR. COTSWOLD CROSS.

	Treatments						S.E. Mean	Differences
	1 Stable Manure	2 Drained Sludge	3 Town Refuse Compost	4 Meat & Bone Meal	5 N P	6 Nil		
Year								
1945	1.14	1.36	1.39	1.51	1.41	1.40	0.160	Not significant
1946	2.06	2.52	1.97	2.78	2.74	1.59	0.228	Significant at 5% level P
Order	(4)	(3)	(5)	(1)	(2)	(6)		

The significant difference at 5% level of P was 0.687.

Treatment 4 > 1, 3, 6; 5 > 3, 6; 2 > 6.

Yield of Fruit: 1945. The crop was small, with no significant differences.

1946. The crop was good, with no significant differences due to treatments. The results are given in Table VI.

TABLE VI.

YIELD OF FRUIT FROM VAR. COTSWOLD CROSS. 1945: MEAN WEIGHT IN LBS. PER PLOT. 1946: MEAN WEIGHT IN LBS. PER BUSH.

Year	Treatments						S.E. Mean	Differences
	1 Stable Manure	2 Drained Sludge	3 Town Refuse Compost	4 Meat & Bone Meal	5 N P	6 Nil		
1945	5.19	5.19	4.19	4.75	4.44	5.17	0.579	Not significant
1946	4.14	4.20	4.02	4.31	4.23	3.48	0.435	Not significant
Order	(4)	(3)	(5)	(1)	(2)	(6)		

Leaf Analysis. Mature leaf samples were taken from current growth on 24.6.46 and analysed for total calcium, magnesium, potassium, phosphorus and nitrogen. The results are given in Table VII.

The mineral status of the leaves on all plots appears to be satisfactory with the exception of nitrogen which is satisfactory in treatments 2, 4 and 5, but approaching deficiency level in treatments 1 and 3, and deficient in treatment 6. This confirms the visual symptoms previously described.

Acknowledgments.

The sewage sludge and straw-sludge composts were supplied by the Bath City Council (Engineer's Dept.) and the town refuse compost by the London County Council. The co-operation of these Authorities is gratefully acknowledged and best thanks are due to Mr. J. Owens, City Engineer, and Mr. N. Priest, sewage works manager, Bath, and to Mr. Warlow of the L.C.C.

SUMMARY.

1. A field experiment to test the effect of certain organic manures (applied on an equal organic matter basis) on the growth, yield and chemical composition of two varieties of black currants is described.

2. During the first season, treatments had no effect on growth or yield of fruit. During the second season, significant differences were produced on growth, but treatments had no significant effect on yield of fruit.

3. During the second season, treatments produced significant differences in the K_2O , P_2O_5 and N content of leaves. The mineral status of the leaves was satisfactory, except in the plots treated with stable manure and with composts. These dressings did not liberate sufficient nitrogen to maintain a satisfactory nitrogen level.

TABLE VII.
EFFECT OF MANURIAL TREATMENTS ON THE CHEMICAL COMPOSITION OF MATURE BLACKCURRANT LEAVES VAR. COTSWOLD CROSS.
ALL VALUES ARE THE MEANS OF FOUR PLOTS AND ARE EXPRESSED AS A PERCENTAGE OF DRY MATTER.

	Treatments					S.E. Mean	Treatment Difference	Significant Difference
	1 Stable Manure	2 Drained Sludge	3 Town Refuse Compost	4 Meat and Bone Meal	5 N.P	6 Nil		
CaO	2.77	2.79	2.53	2.67	2.83	2.62	Not significant	—
MgO	0.499	0.483	0.464	0.476	0.512	0.467	Not significant	—
K ₂ O	2.10	1.87	1.87	1.91	1.83	2.07	*	* 0.1707
P ₂ O ₅	0.687	0.586	0.580	0.584	0.601	0.614	**	** 0.0708
N	2.717	3.072	2.787	2.942	2.972	2.620	**	** 0.161

* Significant at 5% level *P*.
K₂O: 1 > 2, 3, 4, 5; 6 > 5, 2, 3.
N: 2, 5 > 1, 3, 6; 4 > 1, 6; 3 > 6.

** Significant at 1% level *P*.

P₂O₅: 1 > 2, 3, 4, 5, 6.

A TECHNIQUE FOR LARGE SCALE POT SAND CULTURES.

By E. J. HEWITT.

The study of nutritional interrelationships and disorders in plants under controlled conditions is conveniently done in sand or water cultures. Where problems of trace element nutrition are involved particular attention must be paid to refinement of the basic materials and equipment used. Special problems of technique arise when large numbers of different crop plants are grown simultaneously on a large scale. This paper describes a satisfactory technique in which simple materials are adapted or refined for use in large scale experiments including those with certain trace elements, when highly-refined or pure materials are either unobtainable or otherwise unsuitable for such work. The materials in their simplest form include clay flower pots with a central drainage hole; a "pure" silica sand obtained from Leighton Buzzard in Bedfordshire; rainwater collected from the roof of the large greenhouse used to shelter the cultures; recrystallised or analytical-reagent grade nutrient reagents. The use of each of these materials is considered separately in the following sections.

POTS.

Clay flower pots are used, as reliable glazed vessels are not obtainable in the size or numbers required, and inferior glaze may be totally unsuitable (11), (20) without the merit of low cost. Pyrex glassware, although one of the most unreactive materials for many purposes (15), (20) is not suitable for boron deficiency (12), (13). It is not easily obtained in large sizes; the difficulty of providing satisfactory drainage as well as liability to breakage are further disadvantages, particularly where the highest level of refinement is not essential.

Ten-inch pots are used for most work with vegetables. A 40 or 60 mesh copper gauze sealed over the drainage hole with paraffin wax and covered by a "crock" retains the sand. The gauze and "crock" can be replaced by a glazed perforated porcelain filter disc and glass wool where necessary, as for example when acid-purified sand is used; these can also be cleaned in strong mineral acids.

As most plants obtain sufficient of many nutrient elements, and particularly of calcium or boron, from the untreated clay pots to maintain normal growth when these elements are omitted from the nutrient solutions (5), it is necessary to treat the pots to prevent such contamination. Several treatments, including paraffin wax linings, synthetic resin lacquers, acid extraction and bitumen paint in addition to the possible value of two thermo-plastics namely, polythene and cellulose acetate, have been examined. Of these the bitumen paint and polythene are outstanding; the others have various disadvantages which render them less suitable or ineffective. Clay pots lined with three coats of a pure bitumen solution are satisfactory for the study of deficiencies of nitrogen, phosphorus, potassium, calcium, iron magnesium, manganese and boron in a wide range of crop plants. This lining is non-toxic and durable for at least one season. Polythene pots have proved particularly satisfactory in the study of iron and boron deficiencies, and this material merits especial consideration as a substitute or lining for clay pots.

SAND.

The sand used in these experiments is a "pure" silica sand, and 90 per cent. is retained between 20 and 40 mesh sieves. The principal impurity is iron, which may occur in several forms, including iron oxide and sandstone concretions, iron-bearing silt, and iron-stain on the surface of the grains, particularly in minute pits or crevices. The average analysis of such sand is as follows:—Iron, 187 ppm.; manganese, 2.3 ppm.; boron, 0.57 ppm.; calcium may be present to the extent of 30 ppm. Examination of the coarser fractions containing the iron sandstone concretions shows that molybdenum, copper, zinc, manganese and boron are all relatively concentrated in this fraction. This information is of value in the purification of sand for trace element experiments. This purification is done in three stages.

The sand is first air-dried and sieved through an 18 mesh sieve of pure copper gauze (where deficiencies of iron, manganese, boron and molybdenum

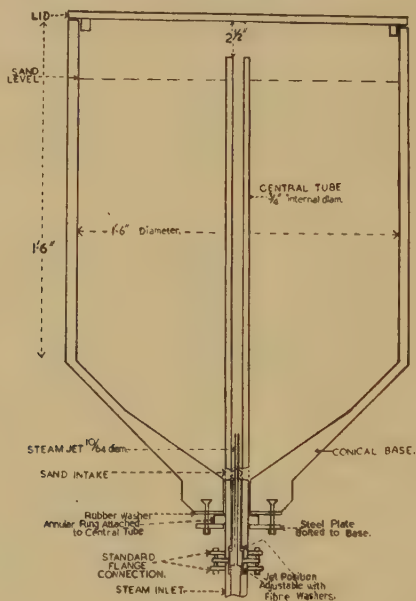


Fig. 1.

are to be studied) and is retained on a second (60 mesh) sieve. The sifted sand is purified by treatment with steam and a hydrochloric-oxalic acid mixture of 12–15% and 0.5% initial concentrations, respectively. The oxalic acid greatly facilitates the removal of iron impurities (1), (2), (3). In order to deal with several tons of sand required each season an automatic apparatus has been designed in which the sand and acid are continuously circulated and heated by the steam. The apparatus is shown diagrammatically in figure 1. The whole apparatus (except for external flanges) is constructed in an acid-resisting material called "Keebush" and is made mainly from standard parts. The 18 gallon vessel has a conical base which ensures that all sand is circulated and that untreated pockets do not occur. The central tube has an alternating double tier of $\frac{1}{2}$ " holes at the base, and an internal diameter of $\frac{3}{4}$ "; it extends almost to the lid of the vessel. The steam jet, of 10/64 inch internal diameter, projects about $1\frac{1}{4}$ " beyond the upper limit of the holes. The jet is held in the

enlarged portion of the central tube and elbow by adjustable fibre washers. The central tube is held in the base of the vessel by a plate bolted to the base which supports a ring fixed to the central tube. Rubber sheet-washers make acid-tight seals. The vessel is loaded with 250 lb. of sand to about 2" from the top; the steam pressure used for operation is 17 pounds per square inch. Steam is admitted gently while the acid is added, and also during unloading.

The acid-purified sand is finally rinsed to remove the acid. Free acid is first removed by leaching with water in an acid-proof sink. The treated sand is highly adsorptive (10) and is saturated with hydrogen ions. These are liberated when the sand is brought into contact with nutrient solutions and cause injury to plants unless removed before use (3). Removal is done by leaching the sand with nutrient solution (suitably purified for the type of deficiency to be studied) until the pH of the nutrient solution remains practically unchanged on standing overnight in contact with the sand. Sand treated by the steam and acid process is suitable for experiments with iron, manganese and boron deficiencies (4), (5) and promising results have also been obtained in preliminary experiments with molybdenum deficiency in some brassica crops (3).

For major element experiments the sand is normally not purified, but is leached with water before use. The solid iron impurity is readily available and this fact has been of value in distinguishing the specific injury caused by manganese toxicity (3), (6), (21) from symptoms of manganese-induced iron deficiency (18), caused by an unfavourable ratio of manganese to soluble iron in the nutrient solution. When necessary the slight calcareous impurity can be largely removed by saturating the sand for a few days with cold 2% hydrochloric acid and leaching with water before use.

WATER.

The provision of an adequate supply of water of sufficient purity is essential to the technique and presents special problems when large scale experiments are undertaken. Rainwater is used to maintain the majority of the cultures, and is collected from the well-leached glass roof of the house used to shelter the cultures. The water is stored in elevated bitumen-painted galvanized tanks. The total storage capacity is about 6,000 gallons, and this is initially filled during the winter and replenished during the season; 12–20,000 gallons are normally used to maintain 1,000–2,000 cultures. Storage in galvanized tanks may lead to acute zinc toxicity effects, but accumulation of zinc is greatly reduced (from 12–15 ppm. to 0.1–1.0 ppm.), and zinc toxicity is prevented, by painting the tanks annually with the pure bitumen solution used for pot treatment. Water stored in old painted galvanized tanks has an appreciably lower zinc content than that stored in new tanks as the latter are less effectively protected by painting until considerable weathering has taken place. The zinc content of water stored in painted old tanks may be only 0.1–0.2 ppm. as compared with 1–4 ppm. in new tanks. Rainwater collected and stored under these conditions shows the following average analysis (as parts per million) for elements of nutritional importance:—Sodium, 0.95; potassium, 1.75; calcium, 1.42; magnesium, 0.18; iron, 0.08; manganese, 0.016; copper, 0.027; zinc, 0.52; boron, 0.013; molybdenum, 0.0009. The values for most elements are generally markedly lower early in the season, and for boron deficiency in particular it is advantageous to use water collected and stored early in the year when the boron content is only 0.005 ppm.

Although the composition of rainwater noted above permits many experi-

ments with major elements to be undertaken and is also suitable for producing acute boron deficiency in several crops (3), (5), the mineral content may be excessive when iron and manganese deficiency effects are to be studied. For these reasons the use of synthetic resin ion-exchange methods of water purification to extend the scope of the experiments that can be undertaken with rainwater (5), (7), and also with tap water (9), merits special consideration. It is not appropriate here to describe the process in detail, but certain aspects require emphasis in relation to nutritional applications. The ionised compounds in water are removed by exchange reactions on two types of resin; one removes cations and a second removes anions. The resins are activated or regenerated with acid and alkali respectively before use. When nearly saturated the ionic concentration in the effluent rises sharply and this is termed breakthrough. The pH of the effluent from the cation exchange unit also

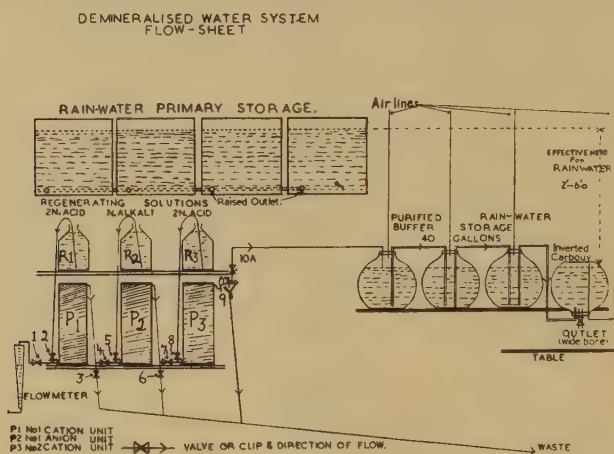


Fig. 2.

risks, but this may be slightly delayed relative to the increase in concentration of some of the cations present.

A convenient arrangement for the purification of rain or tap water is shown diagrammatically as a flow sheet in figure 2. The system is fully automatic when rainwater is used. The elevated storage tanks supply sufficient head to produce the required flow. The purified water is stored in a battery of inter-connected glass vessels. This "buffer" storage is just sufficient to supply the experimental requirements and is kept to a minimum to reduce further storage contamination. The last vessel is inverted to allow rapid delivery of water when required to avoid delay in watering. When full, the water level in the air lines is the same as in the storage tanks, and no water flows in. As soon as water is withdrawn the level in the air lines falls and flow immediately commences and continues at a slow rate so that the system is refilled during the remainder of the day and night after use. The third unit shown as P3 in figure 2 is a secondary cation exchanger and is used to reduce sodium content and to reduce still further traces of other cations.

The efficiency of the process requires comment. It is reversible and is also more efficient at high concentrations than low, as the following example shows:—

Initial concentration ppm.	Final concentration		Efficiency as % removed		
	First cation unit	Second cation unit	by first unit	by second unit	overall efficiency
Calcium 102	1.2	0.15	98.8	87.5	99.85
Magnesium 11.2	0.1	0.0074	99.1	92.6	99.93

The fall in efficiency may set a practical limit to the number of purification cycles and of exchange units usefully employed. It may be noted in passing, however, that additional exchange units have several advantages over recycling once treated water through the same units (9). These are that the subsequent units are less saturated than the first one; they provide a safeguard if breakthrough occurs in the first unit; equipment is simplified, and flow can be made continuous. The efficiency for the removal of some elements, for example boron and molybdenum (which are present as anions), is less than for calcium and magnesium (9), (17), but is still significant (3), (7). Removal of iron is usually considerable, but unionised organic molecules containing this element may not be removed so effectively (8).

The nature of the concentration and pH changes at breakthrough preclude their use to anticipate the need for regeneration and tests to show breakthrough are too late to safeguard the quality of water for nutritional purposes when the continuous process is used. Trial runs are, however, suitable as a means of estimating the capacity of the equipment, which varies with the water used.

Although chemical tests are not used to determine breakthrough, a routine test is still useful. The dithizone test (20) is not appropriate where the water is initially stored in galvanized tanks and the highly sensitive test for manganese using potassium periodate and tetramethyldiaminodiphenylmethane (22) which is quantitative at pH 4.6-5 in sodium acetate-acetic acid buffer (14) is used to detect between 0.001 and 0.1 ppm. of manganese in unconcentrated samples.

Rainwater purified as described compares favourably with distilled water from heavily tinned copper stills with block tin condensers as the following analyses show:—

Sample	Fe	Mn	Cu	Zn	B	Mo ppm.
Distilled water	0.004	0.004	0.014	0.0075	0.003	0.00035 „
Ion-exchange purified water	0.0017	0.005	0.006	0.006	0.004	below 0.0004 „

The method thus provides a supply of several thousand gallons of good quality water for nutritional work.

Ion-exchange purified water has been tested biologically with several crop plants, and is free from toxic constituents as originally found by Liebig et al. (9). Purified tap water is suitable for the study of nutrient interrelations and deficiencies of nitrogen, phosphorus, calcium, magnesium and potassium; and deficiencies of iron, manganese and boron have also been induced in cultures supplied with such purified water. Purified rainwater is suitable for all purposes mentioned above and is particularly useful when iron, manganese and boron deficiencies in many crops are to be studied on a large scale, or where precise work involving nutrient interrelations at low levels is undertaken.

NUTRIENT REAGENTS.

The nutrient solutions are prepared by the dilution of appropriate mixtures of "standard" concentrated stock solutions. These are delivered from a series of several large burettes filled from reservoirs with the aid of compressed air. A given volume of a "standard" stock solution produces a convenient fraction or multiple of the milligramme equivalent weight per litre of the required nutrient element after dilution of the concentrate, each batch of which makes 100 litres of solution for application. The nutrient solution composition is calculated in terms of equivalent ratios, as this assists in the discussion of special problems of nutrient interrelations such as relative toxic effects or the ratio of one element to another. The use of the burettes saves time, assists in accuracy and eliminates errors due to contamination from the use of measuring cylinders.

For experiments with major elements, reagents of recrystallised grade are used. Reagents used for trace element deficiencies require further purification. For the elimination of iron and manganese, the adsorption technique of Steinberg (19), as adapted by Stout and Arnon (20) is used. The efficiency of the method is increased by the inclusion of sodium bicarbonate before heating (3). Nutrient reagents used for boron deficiency are purified by recrystallisation with the addition of alcohol to obtain a high yield, except calcium nitrate, which is prepared from redistilled nitric acid and pure calcium carbonate. Iron compounds used for manganese deficiency are purified by an ether-hydrochloric acid extraction (16).

SUMMARY.

1. Simple materials and equipment including clay flower pots, silica sand, rainwater and nutrient reagents, are used in the pot sand culture technique and each presents special problems of refinement when adapted for large scale trace element experiments.

2. A bitumen paint lining is an effective treatment for pots used in experiments with deficiencies of major elements and of iron, manganese and boron. Polythene is promising as an alternative material for work with trace element deficiencies.

3. Sand for trace element experiments is purified by steam and a mixture of hydrochloric and oxalic acids. An automatic apparatus for the treatment of large batches is described.

4. Unpurified rainwater collected from glass roof and stored in bitumen painted tanks is suitable for experiments with major element and boron deficiencies. Synthetic resin ion-exchange methods of water purification greatly extend the scope of experiments that can be carried out with rainwater. Such purified rainwater compares favourably with water from tinned copper stills and equipment for continuous purification is described.

5. Nutrient solutions are prepared by mixing concentrated "standard" stock solutions delivered from large burettes. For trace element deficiencies the nutrient reagents are purified by appropriate methods depending on the element omitted.

ACKNOWLEDGMENTS.

This work has been carried out as part of the Agricultural Research Council's scheme for plant nutrition with the aid of special grants for which grateful acknowledgment is made.

The ion-exchange water purification units were kindly supplied by the Permutit Co., London, to whom thanks are due for their helpful co-operation.

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PLACEMENT EXPERIMENTS IN THE USE OF FERTILISERS.

PROGRESS REPORT, 1945 and 1946.

By E. J. HEWITT and W. R. STANTON.

This report presents further results obtained by comparing broadcast and liquid placement applications of fertiliser (1). The object of the experiments is to test whether advantages in yields and earliness of crops can be economically obtained by placement methods.

METHODS.

Certain modifications were made in 1946 to the 1945 treatments and, for this reason, the two series of treatments are considered separately.

1945 Treatments.

The plots were the same as those laid out in 1944 (1). The rotations, treatments and yields are shown in Table I. The fertiliser was made by mixing nitrochalk, superphosphate and muriate of potash to give an 8% N, 8% P_2O_5 , 8% K_2O mixture, for the beets, tomatoes and cauliflowers. For lettuce and peas sulphate of ammonia had to be substituted for nitrochalk. The liquid mixture was prepared about 2 hours before application and contained less insoluble material than the "Growmore" used in 1944. It was applied at the same rates as in 1944, which were as follows:—

Starter solution : 10 lb. dissolved in 50 gallons.

Seeded crops 2 pints per 10 feet of drill.

Transplanted crops $\frac{1}{2}$ pint per plant.

Top dressing solution : 20 lb. dissolved in 50 gallons.

Seeded crops 4 pints per 10 feet.

Transplanted crops 1 pint per plant.

Broadcast dressings : 2 lb. per 10 square yards.

Solid top dressings at 4 lb. per 10 square yards applied to individual plants.

1946 Treatments.

The plots were laid out as in the previous two seasons and the rotation and treatments are shown in Table II. The liquid treatments were as follows :

Starter solution : Ammonium phosphate (11% N, 48% P_2O_5).

Cauliflower (I) 4.5 lb. dissolved in 50 gallons ($\frac{1}{2}$ cwt. p.a.).

9.0 lb. do. do. (1 cwt. p.a.).

Applied at rate of $\frac{1}{2}$ pint per plant.

Tomato (I) 9.0 lb. dissolved in 50 gallons (1 cwt. p.a.).

Applied at rate of $\frac{1}{2}$ pint per plant.

Beetroot (Globe and Intermediate).

3.4 lb. dissolved in 50 gallons ($\frac{1}{2}$ cwt. p.a.).

6.8 lb. do. do. (1 cwt. p.a.).

Applied at rate of 2 pints per 10 ft. run of drill.

Top dressing solution : Nitrochalk (11% N.).

Cauliflower (II) } 9 lb. dissolved in 50 gallons.

Tomato (II) } $\frac{1}{2}$ pint per plant.

Yield Data.

Yield data for the year 1945 are given in Table I and for the year 1946 in Table III.

RESULTS.

Transplanted Crops.

Starter solutions. The results of the 1944 experiments were confirmed in 1945-46 for cauliflowers, viz. the increased yield obtained by the use of starter solution, at the early cuttings (1945, 1946 Cauliflower I). Similar confirmation was also obtained for tomatoes (1945, 1946 Tomato I).

In 1946 damage to the foliage of the plants in boxes was caused by treatment D (Tomato I), and it would appear essential to avoid wetting the leaves when giving this treatment. This damage accounted for the low yield of this treatment at the first picking. In 1945 there were no significant improvements due to the addition of starter to boxes (1945 Tomato).

With both tomato and cauliflower in 1945 and 1946, starter solution at

TABLE 1.—CROPS, TREATMENTS AND YIELDS FOR THE YEAR 1945.

Crop	Treatment	Yield (Mean of 4 plots) lbs./plot	Diff's. req'd. for significance at 5% level	Order of Yields
Cauliflower. <i>1st Cuttings</i> 17-23/8/45 Planted: 11/5/45 Var., Majestic following tomatoes	A broadcast only	11.3	3-51	B, C, D, E, A
	B " + liquid starter	17.6		
	C " + water	16.5		
	D " + liquid top dressing	14.5		
	E " + solid top dressing	12.3		
<i>Total cut up to 29/9/45</i>	A	16.9	3-65	B, D, C, E, A
	B	25.3		
	C	20.8		
	D	22.9		
	E	19.7		
Tomato <i>1st Pickings</i> 7-20/9/45 Planted: 8/6/45 Var., Market King following cauliflower	A water to boxes	10.6	3-67	F, C, D, B, E, A
	B liquid starter to boxes	19.5		
	C broadcast only	13.3		
	D untreated	12.6		
	E water at transplanting	11.9		
<i>Total Ripe 12/10/45</i>	A	61.7	8-84	F, C, A, B, D, E
	B	60.9		
	C	64.3		
	D	58.2		
	E	56.4		
<i>Total Green 12/10/45</i>	A	123.9	16-01	C, A, B, D, F, E
	B	123.3		
	C	137.3		
	D	121.0		
	E	108.9		
Leeks. <i>Lifted</i> 19/2/45 Planted: 14/8/45 Var., Nusselburgh following lettuce	A untreated	20.5	6-79	C, B, D, A
	B water at planting	28.4		
	C liquid starter at planting	29.4		
	D broadcast only	21.5		
Beetroot <i>Globe, Lifted</i> 10/9/45 Sown 16/5/45 Var., Detroit	A untreated	lbs./4 plot 152.5	29-0	D, C, B, A
	B water at drilling	156.1		
	C liquid starter at drilling	160.1		
	D broadcast dressing	206.9		
<i>Sown 16/5/45</i> <i>Intermediate Lifted</i> 19/9/45 Planted: 14/8/45. Sown 16/5/45 Var., Cheltenham Green Top following beet	A	lbs./4 plot 31.1	17-6	D, B, C, A
	B	42.6		
	C	41.8		
	D	58.4		
Cabbage Lettuce <i>Chili, Lifted</i> 6/4/45 Drilled 6/4/45 Var., All the Year Round following leeks	A untreated	lbs./plot 50.0	29-2	D, B, C, A
	B liquid starter + liquid top dressing	64.5		
	C liquid starter only	56.4		
	D broadcast only	81.5		
Peas <i>Picked</i> 29/8/45 Drilled 6/4/45 Var., Onward following lettuce	A untreated	34.6	Difference not significant at 5% level	B, D, A, C
	B liquid starter	35.1		
	C liquid starter + liquid top dressing	34.4		
	D broadcast only	35.0		

TABLE II.
CROPS AND TREATMENTS FOR THE YEAR 1946.

Crop Date Planted or Sown, Variety, Previous Crop	General Base Dressings to all Plots	Treatments	Date of application of Treatments
Beetroot Drilled 25/5/46 Varieties (in alternate rows) Detroit Red Globe, Cheltenham Green Top following Peas	1 cwt. p.a. Muriate of potash	A untreated B starter solution at $\frac{1}{2}$ cwt. p.a. C starter solution at 1 cwt. p.a. D broadcast at 2 cwt. p.a.	At Drilling " "
Cauliflower I Planted 18/6/46 Variety, Majestic following Tomatoes	1 cwt. p.a. Muriate of potash 3 cwt. p.a. Nitrochalk	A untreated B water only C starter solution at $\frac{1}{2}$ cwt. p.a. D starter solution at 1 cwt. p.a. E broadcast at cwt. p.a. F broadcast at 2 cwt. p.a.	At Planting " " " " " " " "
Cauliflower II Planted 21/6/46 Variety, Majestic following Beetroot	2 cwt. p.a. Nitrochalk 3 cwt. p.a. Superphosphate 1 cwt. p.a. Muriate of potash	A untreated B liquid top dressing at 1 cwt. p.a. C liquid top dressing at 1 cwt. p.a. (twice) D solid top dressing at 2 cwt. p.a. (twice)	8/7/46 8/7/46 repeated 22/7/46 8/7/46 repeated 22/7/46
Tomato I Planted 24/6/46 Variety, Alsa Craig following Cauliflower	2 cwt. p.a. Muriate of potash	A untreated B water only C starter solution at 1 cwt. p.a. D starter solution to boxes at 5 lb. p.a. E broadcast at 2 cwt. p.a.	24/6/46 24/6/46 17/6/46 24/6/46
Tomato II Planted 6/6/46 Variety, Market King following Lettuce	1 cwt. p.a. Muriate of potash	A untreated B liquid top dressing at 1 cwt. p.a. C liquid top dressing at 1 cwt. p.a. (twice) D solid top dressing at 2 cwt. p.a. (twice)	20/6/46 20/6/46 repeated 8/7/46 20/6/46 repeated 8/7/46

TABLE III.—YIELDS IN THE YEAR 1946.

Crop	Treatments	Treatment Means (Mean of 4 Plots) lbs. per half plot	Diffs. req'd for significance at 5%	Order of Yield
Beetroot Detroit Red Globe	A untreated	60.9	difference not significant	C, D, B, A
	B starter solution at 1 cwt. p.a.	65.4		
	C starter solution at 1 cwt. p.a.	70.6		
	D broadcast at 2 cwt. p.a.	67.9		
Cheltenham Green Top	A } as above	lbs. per half plot	" "	D, C, A, B
	B } as above	45.0		
	C } as above	42.2		
	D } as above	45.7		
Cauliflower (I) 1st Cutting 24/9/46	A untreated	10.0	3.36	D, C, E, B, F, A
	B water only	11.3		
	C starter solution at 1 cwt. p.a.	19.5		
	D starter solution at 1 cwt. p.a.	19.5		
Total Cut (Sum of 1st and 2nd cuttings) latter 23/10/46)	E broadcast at 1 cwt. p.a.	12.7	difference not significant	D, F, E, C, A, B
	F broadcast at 2 cwt. p.a.	11.0		
	A } as above	lbs. per plot		
	B } as above	44.2		
Cauliflower (II) 1st Cutting 16/9/46	C } as above	36.8	" "	D, C, B, A
	D } as above	45.3		
	E } as above	47.1		
	F } as above	45.8		
Total Cut (Sum of 1st and 2nd cuttings) latter 4/10/46)	A untreated	0.5	9.9	C, D, B, A
	B liquid top dressing at 1 cwt. p.a.	2.8		
	C liquid top dressing at 1 cwt. p.a. (twice)	3.6		
	D solid top dressing at 2 cwt. p.a. (twice)	3.8		
Tomato (I) 1st Picking 11/10/46	A } as above	lbs. per plot	1.50	C, A, B, E, D
	B } as above	5.3		
	C } as above	14.3		
	D } as above	27.4		
2nd Picking 18/10/46	E broadcast at 2 cwt. p.a.	24.9	difference not significant	E, C, A, B, D
	A untreated	3.8		
	B water only	3.6		
	C starter solution at 1 cwt. p.a.	5.6		
Picked Green 18/10/46	D starter solution to boxes at 5 lb. p.a.	0.9	5.08	E, C, B, A, D
	E broadcast at 2 cwt. p.a.	3.4		
	A } as above	lbs. per plot		
	B } as above	4.1		
Total Cut (Sum of 1st and 2nd cuttings) latter 4/10/46)	C } as above	3.4	" "	E, C, B, A, D
	D } as above	4.3		
	E } as above	2.1		
	F } as above	5.4		
Tomato (II) 1st Picking 11/10/46	A untreated	27.3	" "	E, C, B, A, D
	B water only	28.5		
	C starter solution at 1 cwt. p.a.	29.5		
	D starter solution to boxes at 5 lb. p.a.	15.3		
2nd Picking 18/10/46	E broadcast at 2 cwt. p.a.	31.0	" "	E, C, B, A, D
	A } as above	lbs. per plot		
	B } as above	27.3		
	C } as above	28.5		
Total Cut (Sum of 1st and 2nd cuttings) latter 4/10/46)	D } as above	29.5	" "	E, C, B, A, D
	E } as above	15.3		
	F } as above	31.0		
	G } as above	31.0		

TABLE III *cont.*

Crop	Treatments	Treatment means (mean of 4 plots)	Diff's. req'd. for significance at 5% level	Order of Yield 1	Order of Yield 2
Tomato (II) 1st Picking 5/9/46	A untreated	lbs. per plot* 2	1 2		
	B liquid top dressing at 1 cwt. p.a.	3.8			
	C liquid top dressing at 1 cwt. p.a. (twice)	4.0	difference between treatments & error not significant	B, A, C, D	
	D solid top dressing at 2 cwt. p.a. (twice)	3.3 2.9			
2nd Picking 17/9/46	A } as above	10.4			
	B } as above	11.2		B, A, D, C	B, A, D, C
	C } as above	9.3			
	D } as above	9.9			
3rd Picking 25/9/46	A } as above	24.0			
	B } as above	21.0		C, A, B, D	A, C, B, D
	C } as above	24.5			
	D } as above	17.5			
4th Picking 30/9/46	A } as above	28.5			
	B } as above	35.3			
	C } as above	37.3	1 2	C, B, D, A	C, B, A, D
	D } as above	32.3	Difference not significant		
5th Picking 5/10/46	A } as above	30.8			
	B } as above	42.3		B, C, D, A	C, B, D, A
	C } as above	40.8			
	D } as above	36.8	difference not significant		
6th Picking 11/10/46	A } as above	33.4			
	B } as above	30.9			
	C } as above	25.0		D, A, B, C	B, C, D, A
	D } as above	33.4			
7th Picking (green) 11/10/46	A } as above	31.3			
	B } as above	34.5		D, C, B, A	B, C, D, A
	C } as above	38.5			
	D } as above	42.5			

* 1. Weight yielded at each picking.

2. Sum of weights yielded up to and including particular pickings.

averages on the limed plots—the values including unlimed plots are lower but are in essentially the same order.

Nil	N.P.K.	P.K.	N.K.	K.	N.P.	P.	Nil
2.0	5.2	4.2	3.7	3.0	3.7	2.5	2.2

It appears from these values that deficiencies of P and K produced similar decreases in vigour and that the effects of nitrogen deficiency were somewhat less serious than those resulting from P or K.

Visual Symptoms. The main effects of the various treatments may be observed in Table I by examining the symptoms recorded on the “no lime” strips and on each fertiliser strip. It will be seen that where no lime was given —Ca, —Mg, —K, +Mn occurred on each strip and that —P was evident on three of the strips.

The main effects shown in examining the results on the fertiliser strips are as follows :—

The Nil plots show the fewest symptoms and whilst on the Plot 1 side of the area there is a tendency for —Ca effects, on the Plot 8 side the tendency is for —K effects, suggesting a lower K status on the Plot 8 side, which is supported by the chemical data in Table II.

The following are the main effects shown in the fertiliser strips :—

Treatment	N.P.K.	—Mg as most common symptom
”	P.K.	” ” ” ” , but also few —N
”	N.K.	—P and some —Mg
”	K.	—Mg and —P, also one —N
”	N.P.	—K
”	P	—K

Thus where N.P. and K are all given, magnesium is at deficiency level, and indeed is so whenever K is included in the fertiliser treatment. Deficiency of P. in N.K. treatment appears to decrease —Mg symptoms to a slight extent, an observation also made on plots at Long Ashton.

—P symptoms are prevalent where phosphorus is omitted (N.K. and K treatments) and are restricted to these two treatments. —K symptoms are common where potassium is omitted (N. P. and P. treatments), but also occur on the nil plots adjoining these treatments.

Chemical Data. The data in Table II are grouped in two sections, for the unlimed plots 1—8 and for those receiving lime treatment, plots 9—16. This arrangement enables an easy comparison to be made of the effects of the lime treatment under all fertiliser treatments. The outstanding points of this comparison are the differences in calcium and manganese levels in the two series, from which it is clear that the liming treatment has substantially raised the calcium status and lowered the manganese level under all manurial treatments.

Other points of interest which may be seen in the full chemical data are as follows : potassium levels are higher in the limed series where potash fertiliser is applied, which must result either from increased availability in the soil or from improved intake by the plant ; magnesium levels in the two series are on the average fairly similar but the effect of potash manuring shows a sharper difference in magnesium level in the unlimed series ; unlike potassium, the levels of phosphorus are higher in the unlimed series where phosphates are applied and for this no reason can at present be given ; in both series, in the manured plots, the level of manganese is lower where potash manuring is given

TABLE II.
SHOWING THE RELATION BETWEEN VIGOUR MARKING, VISUAL SYMPTOMS, FULL CHEMICAL AND TISSUE TEST DATA FOR K, Mg, Ca, P, Mn.

Plot	Manurial Treatment	Crop Vigour Max. = 10	Visual Symptoms	Full Chemical Data				Tissue Test Data *						
				As % Dry Matter.				in parts per million		K	Mg	Ca	PO ₄	Mn
				K ₂ O	MgO	CaO	P ₂ O ₅	Mn						
1	Nil (no lime)	1	Ca deficiency	3.06	0.64	0.70	0.32	390	M	H—	H—	L+	M—	H++
2	N P K "	2	Ca and Mg deficiency and Mn toxicity	2.01	0.30	0.82	1.12	540	M—	L+	L+	L+	H	H++
3	P K "	2	"	2.18	0.42	0.54	0.57	457	M—	M—	M—	L+	M	H++
4	N K "	3	Ca deficiency and Mn toxicity	2.56	0.37	0.78	0.62	303	M—	M—	M—	L+	M	H++
5	K "	2	Ca and Mg deficiency and Mn toxicity	3.82	0.43	0.63	0.38	326	M	M—	M—	L+	M—	H++
6	N P "	3	K deficiency habit Mn toxicity	2.89	0.62	0.96	0.53	485	M	M+	M+	M—	M	H++
7	P "	3	K deficiency and Mn toxicity	2.76	0.65	1.0	0.57	620	M—	H—	H—	M—	M	H++
8	Nil "	1	K deficiency habit, Mn toxicity	1.88	0.50	0.80	0.40	639	M	H—	H—	L+	M—	H++
9	Nil + Lime 9 tons per acre	2	Mg deficiency	4.12	0.36	4.01	0.58	130	H—	M	M	M	M	Tr++
10	N P K "	6	"	5.62	0.40	4.52	0.63	141	H—	M—	M—	M+	M+	Tr++
11	P K "	5	"	4.85	0.30	3.62	0.42	128	H—	L+	L+	M	M	Tr++
12	N K "	4	Mg and P deficiency	5.24	0.42	3.92	0.28	117	H—	M—	M—	M+	L+	Tr++
13	K "	3	Mg and P deficiency	5.86	0.52	4.06	0.30	136	H	M	M	M+	L+	Tr++
14	N P "	4	K deficiency habit	1.23	0.63	5.02	0.46	152	L+	M+	M+	H—	M—	Tr+
15	P "	2	K deficiency	1.78	0.58	5.36	0.30	156	L+	M+	M+	H—	L+	Tr+
16	Nil "	1	K deficiency habit	2.12	0.48	5.42	0.28	162	M	M	M	H—	L+	Tr+

* Quantitative equivalents of the High (H), Medium (M), Low (L) and Trace(Tr) categories for the nutrients may be obtained from a paper by one of us (D.J.D.N.) in the 1945 report (2).

planting gave a significantly greater yield than water at planting. For leeks (1945), however, there was no difference between water and starter solution.

Seeded Crops.

Starter solution. In 1944 the effect of liquid treatments on seeded crops was deleterious (lettuce and beet). Beetroot in 1945 showed an increase in yield which did not reach a significant level with the use of water and starter solution at drilling. The only significant increase was given by the broadcast dressing. In 1946 the starter solution gave an increased yield with globe beet, though this again was not significant, nor was the increase due to the broadcast dressing. Cabbage and lettuce behaved similarly to beetroot in 1945 giving a significant increase with a broadcast dressing. There were no significant differences between the treatments for peas (1945).

Top dressing solution. The only crop on which this type of treatment was used in 1945, was lettuce and the results were not significant. In 1946 the double application of a liquid top dressing (Tomato II) showed a significant difference at the 4th picking, but this increased weight was not sustained over any of the picking period as shown in column (2) (Table III).

For cauliflower II (1946) there was no significant difference between the yield for equal weights of nitrochalk when applied as solid or liquid top dressings.

Summary.

1. Experiments commenced in 1944 were continued in 1945 and 1946 to test the advantages of solid and liquid methods of fertiliser placement on tomato, cauliflower and leeks as transplanted crops and on beetroot, lettuce and peas as seeded crops.

2. Transplanted crops consistently benefited from the use of starter solutions.

3. Seeded crops did not respond to starter solutions but gave improved yields with broadcast dressings.

4. The increase in early yields of tomatoes obtained in 1944 by the application of a starter to seed boxes a week before transplanting was not confirmed.

Acknowledgments.

This work has been continued as part of the Agricultural Research Council's scheme for plant nutrition; thanks are due to Mrs. J. Emery and Miss E. Prescott for assistance in applying treatments and recording.

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THE RESOLUTION OF THE FACTORS IN SOIL ACIDITY: SOME EFFECTS OF MANGANESE TOXICITY.

By E. J. HEWITT.

The problems associated with injury to crops caused by acid soils are complex. Some of the more important factors involved have been given in previous papers (5), (13), and visual evidence was obtained that manganese toxicity is the principal factor responsible for typical injury shown by cauliflower and runner bean growing in acid soils. Further work has shown that crop susceptibility to manganese toxicity may vary greatly and this paper describes some of the effects produced by excess manganese on a range of crop plants grown in sand cultures and their relation to effects seen in acid soils.

EXPERIMENTAL.

Materials and Methods.

The rainwater technique described in previous papers (4, 5) was used in these experiments. The sand was not purified by acid treatment and thus supplied iron in a solid but available form in addition to that supplied in solution as ferric citrate and also contained 30 ppm. of calcium. The standard nutrient solutions used were adjusted to pH values of 5.5 and 3.0 with sulphuric acid and had the composition shown in Table I below.

TABLE I.
COMPOSITION OF BASAL NUTRIENT SOLUTIONS USED.

Nutrient salt	"Omitting" and "low" Calcium	"High" Calcium
	g. weight in 100 litres	g. weight in 100 litres
KNO ₃	20.4 (30.6 for tomato)	20.4 (30.6 for tomato)
Ca(NO ₃) ₂	—	65.6 (49.2 for tomato)
NaNO ₃	68.0 (51.0 for tomato)	—
NaH ₂ PO ₄ , 2H ₂ O	10.4	10.4
MgSO ₄ , 7H ₂ O	37.0	37.0
Na ₂ SO ₄ , 10H ₂ O	8.9	8.9

Iron and trace elements were supplied as stated previously (4). The rainwater used for the "omitting" and "low" calcium treatments contained up to 1.5 ppm. of calcium in soluble form. The "omitting" and "low" levels of calcium were differentiated by the nature of the pot treatments which were double and single waxed respectively (4). Single waxed pots were also used for the "high" calcium treatments which were maintained with tap water and thus supplied an additional 102 ppm. (5.1 milli-equivalents per litre (meq/l.)) of calcium in soluble form. The level of phosphate supplied was again low as in 1945 (5). Excess manganese was supplied as the sulphate at concentrations ranging from 0.8 to 24 milli equivalents per litre (22 to 660 ppm.) of manganese according to the susceptibility of the various crops examined.



Fig. 1. Cauliflower leaves: A: Calcium deficiency symptoms—interveinal necrotic mottling, backward curling of margins and 'hooking' of leaf tip. B: Manganese toxicity symptoms—forward cupping of margins, marginal and interveinal necrosis and distortion.

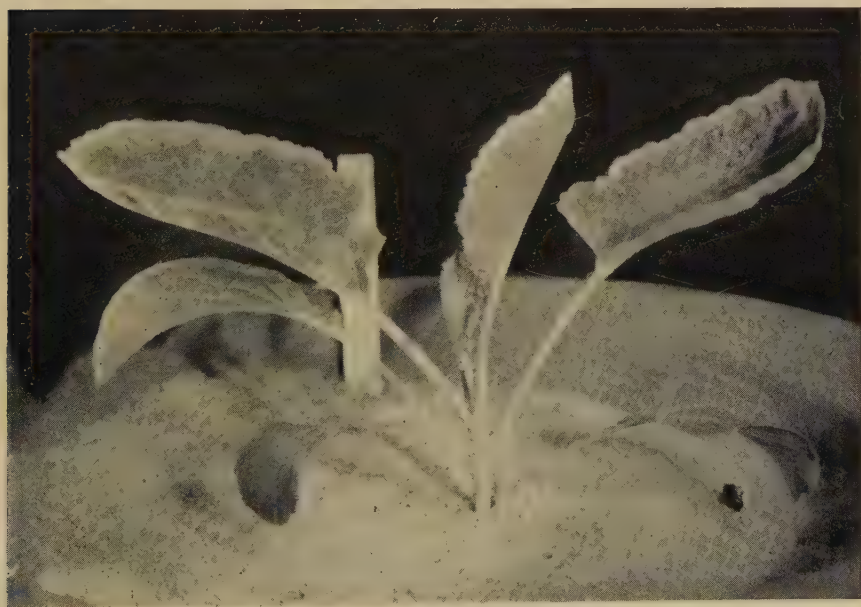


Fig. 2. Savoy cabbage: Symptoms of manganese toxicity—white or yellow-green marginal 'rim' effect and slight cupping of leaves.

The crops grown and the treatments given are shown below in Table II.

TABLE II.
CROPS GROWN AND TREATMENTS GIVEN.

Crop	pH value	Treatment given
Barley	3.0 & 5.5	"Omitting" calcium; normal and excess manganese
Oat	3.0 & 5.5	"Low" and "high" calcium: ,, ,, "
Cauliflower ..	3.0 & 5.5	"Omitting," "low" and "high" calcium ,,
Savoy cabbage ..	3.0 & 5.5	"low" and "high" calcium ,,
Mustard	3.0 & 5.5	"Omitting" calcium ,,
Rape	5.5	"Low" and "high" calcium ,,
Swede	5.5	"Omitting" calcium ,,
Hungry gap kale ..	5.5	"Low" and "high" calcium ,,
Red clover	5.5	"Low" and "high" calcium ,,
Sugar beet	3.0 & 5.5	"Low" and "high" calcium ,,
Mangold	5.5	"Low" and "high" calcium ,,
Potato	3.0 & 5.5	"Omitting" "low" and "high" calcium ,, "Omitting" potassium, and omitting both calcium and potassium ,,
Tomato	5.5	"Omitting" "low" and "high" calcium ,,
Flax	5.5	"Omitting" calcium ,,
Meadow Fescue & Perennial Ryegrass	5.5	"Omitting" calcium ,,

Results.

The detailed visual data are given in the form of an appendix at the end of this paper. The more important effects only, noted in some of the crops studied, are given here. The results obtained with the cauliflower confirmed those observed in 1945 (5); forward marginal cupping was marked but a narrow white rim effect was also observed in young plants given excess manganese. Increased calcium in soluble form antagonised manganese intake and reduced the severity of the symptoms. Acute calcium deficiency was induced by the omitting calcium treatment; backward marginal curl of the younger leaves and tip hooking, and intervenal wilting and collapse within the margins of the middle leaves were typical. These symptoms were distinct from those of manganese toxicity. The two effects are shown in figure one.

The savoy cabbage responded to excess manganese by producing a marked cream or green-white chlorotic rim effect round the margin of the older leaves. Cupping was only slightly developed in contrast with the cauliflower. These symptoms appear identical with those shown by savoy cabbage plants in acid soils and are shown in figure two. Further details are given in the appendix. The white rim effect and marginal cupping in both savoy and cauliflower were associated with an accumulation of soluble manganese and also of calcium in these tissues as shown in Table III.

TABLE III.
DISTRIBUTION OF MANGANESE IN LEAF OF CAULIFLOWER AND SAVOY CABBAGE.
LEVEL OF EXCESS MANGANESE 3 MEQ/L. (82.5 PPM).

Test for		Cauliflower			Savoy cabbage		
		midrib	intervenal areas	leaf margin	midrib	intervenal areas	leaf margin
Ca++	ppm	50	100	200	80	80	150
Mn++	ppm	23	70	115	34	46	120

Manganese toxicity in swede resulted in marked forward cupping but this was less marked than shown by cauliflower. Combined calcium deficiency and manganese toxicity produced cupping, distortion of the younger leaves and intervenal grey tinting, necrosis and wilting of older leaves in addition to a chlorotic rim effect and scorching. These symptoms were similar to those often seen in swedes growing in acid soils.

Hungry gap kale and rape were less sensitive to manganese toxicity, and showed only slight grey necrotic effects. Rape was however sensitive to calcium deficiency and produced a typical intervenal grey wilting in the middle leaves. Mustard on the other hand was severely injured by excess manganese and this was particularly marked at the lower pH value of 3.0.

Oat was also among the less sensitive crops to the effects of manganese toxicity. No injury was produced by the maximum concentration of 3.0 meq/l., *i.e.* 82.5 ppm., although a trace of chlorosis suggestive of iron deficiency was observed. Barley, however, was readily affected by manganese toxicity; the symptoms (recorded in the appendix) were characteristic and also distinct from iron deficiency. The symptoms shown by perennial rye grass and meadow fescue resembled those seen in barley.

The effects of excess manganese in red clover were slight marginal cupping, irregular intervenal necrosis and necrosis in the main veins later, followed by chlorosis, necrosis and distortion of young leaves. This crop was less sensitive than cauliflower.

Sugar beet and mangold were remarkably resistant to manganese toxicity. Mature sugar beet plants were undamaged by 24 meq/l. (660 ppm.) of manganese and seedlings germinated and grew normally during winter months in concentrations up to 220 ppm., except for slight stunting and paling. Similar effects were observed with mangold.

The symptoms of manganese toxicity in tomato included collapse of basal leaflets, black necrosis of major veins and dark green-brown sunken lesions on the stems particularly around leaf bases; plants were generally taller than controls. Flax was not susceptible to manganese toxicity at concentrations up to 3.0 meq/l. (82.5 ppm.) of manganese.

Symptoms of manganese toxicity in potato were not only modified in severity by calcium supply as noted below, but also in characteristic appearance. The typical "acidity plants" resemble closely those produced by a combination of "omitting" calcium and excess manganese treatments or by acute calcium deficiency alone according to soil circumstances. The severe effects produced by a combination of "low" calcium and excess manganese treatments are more rarely seen in the field but are not unknown. An unusual symptom termed "central necrosis" has been observed in potatoes growing

on unlimed plots from which potash was also withheld on a highly acid soil pH 3.9 (9) (14), and is described in detail in the appendix to this paper. This symptom and associated effects was reproduced in many essential details by a combination of the dual omission of calcium and potassium with excess manganese.

Although the effects of manganese toxicity appeared in diverse forms in the different crops studied there were certain common or analogous features. Vascular necrosis was noted in tomato, potato, clover, mustard and in the marginal regions of leaves of savoy. Cupping appeared in cauliflower, swede, clover and to a slight extent in savoy. Marginal paling or chlorosis was seen in savoy, swede, cauliflower and clover. Collapse of leaves or leaflets and stem lesions were shown by tomato and potato. Black or purple fine speckling was seen in runner bean (5), mustard, potato.

Instances in which chlorosis suggestive of iron deficiency occurred, were rare even when severe manganese toxicity injury was observed. With the exception of oat, there were no cases of straightforward iron deficiency in which a clear-cut response was obtained to the application of iron containing sprays or dipping. The chlorosis observed in the potato may well have been associated with the effects of potassium deficiency (12).

The protective effect of increased soluble calcium already noted for cauliflower was also evident in different degrees in savoy, kale, rape, clover, tomato and potato. Increased soluble calcium greatly delayed the appearance of manganese toxicity effects in many crops and the delaying effect was more pronounced for the less sensitive crops. Quick chemical tests for soluble nutrients confirmed that increased soluble calcium in the nutrient depressed the accumulation of manganese. Reduced pH, however, frequently had an opposite effect and permitted greater accumulation of soluble manganese in the tissues of some crops.

DISCUSSION.

The results of these experiments provide further indication that complex soil problems such as that of soil acidity may be elucidated by visual means. These experiments show that the many of the typical effects of growth in acid soils can be reproduced in cauliflower, savoy cabbage, swede, potato and also runner bean (5) by suitable combinations of manganese toxicity and inadequate calcium supply.

Thus swede, rape, potato and occasionally cauliflower may suffer from calcium deficiency. Potato and swede frequently show effects of combined calcium deficiency and manganese toxicity. The most frequently injurious factor for cauliflower, savoy cabbage and runner bean is manganese toxicity.

The sugar beet presents points of particular interest. This crop often fails at pH values about 5.0 and sometimes above this value, when other crops and particularly potatoes may not be severely affected. The latter, however, in common with many others, is considerably more sensitive to manganese toxicity effects in sand cultures than sugar beet. The elucidation of this point will be the subject of a subsequent paper.

Finally, the relation of manganese toxicity to iron deficiency and its significance in acid soils requires consideration. The results obtained here confirm previous findings (5) that manganese toxicity results in characteristic injury that is distinct from iron deficiency. This is also evident from the work of Hopkins et al. (6) with pineapple and beans and in earlier work by Kelly (7) on the manganiferous soils of Hawaii. In the latter case pineapple showed

iron deficiency, but other crops showed injury apparently distinct from this symptom. Unpublished work by the writer using a refined technique with sand purified from iron compounds confirms the findings of others (1), (6), (10), (11) using water cultures, that increasing quantities of manganese accentuate symptoms of iron deficiency. In the presence of iron in solid but available form however, such chlorosis does not readily appear, and characteristic injury distinct from iron deficiency is observed in the presence of excess manganese. In these refined experiments with sugar beet, which is notable for its relatively high susceptibility to iron deficiency in certain circumstances in the field and in sand culture, the number of plants showing chlorosis, and the severity of symptoms, was reduced by increase in the concentration of soluble iron even when accompanied by a greater manganese-iron ratio. The case reported by Hopkins et al (6) was exceptional in that the highly acid soil was almost devoid of available iron but still high in manganese. Most acid soils have adequate available iron (2), (3), (8), and this may account for the infrequent observation of iron deficiency in such soils.

SUMMARY.

1. Several crop plants were grown in sand cultures and given various combinations of excess manganese and calcium deficiency treatments.

2. A great diversity of symptoms ascribed to manganese toxicity was observed, but certain common effects were also discerned.

3. The typical appearance of plants growing in acid soils was reproduced in cauliflower, savoy cabbage, rape, swede and potato by appropriate combinations of calcium and manganese levels in the nutrient.

Unusual symptoms seen in potatoes growing in an acid soil were reproduced by a combination of potassium and calcium deficiency with manganese toxicity.

4. Sugar beet was remarkable for its tolerance to excess manganese.

Hungry gap kale, oat and flax were also relatively unaffected by excess manganese.

5. Increase of soluble calcium in the nutrient depressed the accumulation of manganese in the tissues and reduced the severity of the visual symptoms of toxicity.

6. The visual effects of injury caused by manganese toxicity were distinct from induced iron deficiency.

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APPENDIX.

SECTION A.

SYMPTOMS OBSERVED IN SAND CULTURES—MANGANESE TOXICITY, CALCIUM DEFICIENCY COMPLEX.

Barley.

Omitting calcium, excess manganese; pH 3.0 and 5.5. Tillering reduced to nil by Mn at 220 ppm. 1st and subsequent leaves dark brown elongated, spotting visible first on dorsal side in epidermal cells and becoming sunken, necrotic areas coalescing irregularly and visible on both sides; spotting generally commencing in middle region of leaf between veins but frequently appearing in three main regions adjacent to mid-vein and margins; producing bronze tint in foliage.

Oat.

All treatments: growth vigorous, older leaves slight red-brown "fired" appearance (10 weeks after sowing) followed by irregular intervenal orange mottling commencing from apex (suggestive of mild K deficiency or pH damage).

Low calcium treatments: growth tall, no response to high manganese up to time of grain ripening.

High calcium treatments: growth relatively slightly stunted; high manganese: slight intervenal yellow-green chlorosis younger leaves, suggestive of mild Fe deficiency symptoms; no symptoms of damage.

Grasses.

Meadow Fescue.

Omitting calcium, high manganese: numerous small, slightly elongated, intervenal dark brown spots, mainly visible dorsal surface and producing a bronzed tint, adjacent spots coalescing into larger areas, browning of leaves finally very marked.

Perennial Ryegrass.

Omitting calcium, high manganese: symptoms as above with similar spotting to that observed in Meadow Fescue but spotting more minute, browning and necrosis of leaves very marked.

Savoy Cabbage. pH 3.0

Low calcium treatments: leaves larger and thinner than corresponding high calcium treatments.

Excess manganese treatments: growth stunted; 2 weeks from transplanting expanding leaves marked paling in narrow marginal zone "rim effect" (tissue round extreme ends of veins frequently remaining green); becoming cream or dull white chlorosis and occasional slight mottling spreading inwards intervenally for short distance; relatively pronounced in low calcium treatment, tending to recover after a few weeks but re-appearing on increasing level of manganese; slight forward cupping of first affected older leaves but absent in later leaves (not restored by increases in manganese level); older leaves (in low calcium series) later developing indigo or black tinting along margins and in veins in marginal zone (where formerly white or mottled); intervenal dark brown necrotic spotting, and finally brown marginal scorching, oldest leaves occasionally yellowing, commencing intervenally in central area but remaining mottled yellow and green with necrosis in former white mottled marginal area before dehiscing; petioles old leaves occasionally diffuse irregular indigo markings below epidermis on dorsal side towards base; roots brown but normal.

pH 5.5

Low calcium treatment: no symptoms observed.

Excess manganese treatments, low and high calcium levels: symptoms generally resembling those described above but less pronounced; plants more vigorous; rim effect narrower, and loss of yellow tinting in advanced stages; indigo markings in petioles reduced and appearing later.

Note.—The marginal paling, tinting and necrosis due to excess manganese were relatively less marked in the high calcium treatment but the "protective" calcium effect was not as great

as in cauliflower (below). All the plants made considerable recovery and the symptoms were restored by increasing the manganese level at intervals during the season.

Cauliflower. pH 3.0

Omitting calcium, normal manganese : growth stunted by death of growing point, apex brown, stunted and leafless ; first symptoms : yellow-green mottling between veins of young (not youngest) leaves, rapidly leading to profuse pale brown, fine rounded necrotic spotting about $1/16''$ with pale green marginal zone, marginal constriction near apex and backward curling producing typical tip hooking symptoms, youngest leaves lacking lamina, or brown along margins finally brown stunted petioles ; only 1 plant severe wilting midrib or petioles all younger leaves ; roots very restricted dark brown ; flowering prevented, death of plant.

Omitting calcium, high manganese : first symptoms marked forward cupping of margins of middle and older leaves becoming very severe later, and irregular yellow-green to white narrow rim effect but not outstanding as in Savoy, and relatively more pronounced in middle expanding leaves ; marginal paling spreading intervenally between major veins followed by dark brown spotting in pale areas, also as brown necrotic rings (as well as areas), severe marginal and inter-venal crinkling and distortion ; typical calcium deficiency symptoms noted above appearing subsequently but "wilting" symptoms rare ; tip hooking and backward curl of margins gradually replacing forward cupping (symptoms confused) finally only dead stunted petioles of young leaves as above ; indigo markings on undersides of petioles as in savoy and penetrating deep into cortex ; roots even more stunted having made little growth since transplanting ; no flowers, death of plant.

Low calcium, normal manganese : no symptoms.

Low calcium, high manganese : symptoms of manganese toxicity as described for omitting-calcium series and finally most severe of all groups ; also indigo necrotic spotting at margins and in fine marginal veins, margins tearing and mesophyll perforating between veins, finally lamina ragged and progressively removed by continual necrosis leaving almost bare petioles except for distorted portion of lamina at extreme apex of leaf, pronounced petiole markings, flowering hastened followed by bolting, occasional wilting of pedicles ; roots slightly brown otherwise normal.

High calcium, normal manganese : growth normal.

High calcium, high manganese : manganese toxicity greatly reduced, slight marginal cupping only ; necrosis, distortion and tearing and petiole markings totally absent, but flowering and bolting accelerated as above.

pH 5.5

Omitting calcium, normal manganese : generally resembling symptoms at pH 3.0 but wilting and collapse of mesophyll and veins, midrib and petioles of middle leaves more general ; tip hooking also common in younger leaves ; similar fine profuse necrotic spotting within marginal area, fusing into continuous grey necrotic band ; remaining symptoms as described for pH 3.0.

Omitting calcium, high manganese : similar response as for pH 3.0 ; inter-venal necrosis of two types :—(a) pale brown necrotic areas intervenally similar to above but larger areas, and (b) small blue-black necrotic spots in groups close to veins in margins ; severe distortion and reduction of lamina due to combination of excess manganese necrosis and calcium deficiency ; collapse and wilt of middle and younger leaves mainly in midrib or petiole (c.f. pH 3.0) rather than in mesophyll as for normal manganese ; similar indigo markings backs of petioles and midrib, becoming sunken lesions towards apex ; severe calcium deficiency symptoms eventually obscuring manganese toxicity effects.

Low calcium, normal manganese : no symptoms.

Low calcium, high manganese : marginal cupping and marginal inter-venal necrotic spotting eventually leading to ragged then almost bare petiole except for small distorted "knot" at apex ; brown at extreme apex ; indigo markings base of petioles lower side, less pronounced than above, flowering and bolting accelerated.

High calcium, normal manganese : no symptoms.

High calcium, high manganese : similar to pH 3.0, mild "cupping" absence of other symptoms.

Kale (Hungry gap). pH 5.5

Low calcium, normal manganese : paling centres of middle leaves and slight marginal greying appearing much later than with excess manganese.

Low calcium, high manganese : older leaves with paling margins in narrow zone becoming grey-green and followed by brown inter-venal necrotic spots or larger areas with dark outer zone in marginal region, no further symptoms. Necrosis not observed at lower manganese levels causing relatively severe damage in cauliflower, savoy and potato.

High calcium, normal manganese : no symptoms.

High calcium, high manganese : no symptoms.

Rape. pH 5.5

Low calcium, normal manganese : no symptoms until flowering ; wilting of pedicels in one plant.

Low calcium, high manganese : *older leaves paling at margins and intervenal grey, becoming orange-tinted mottling, followed by intervenal necrotic spotting and greying and curling up and scorching of margins*; dark purple or indigo markings on petioles and base of flower stems; 3 plants premature flowering with wilting of pedicels (10 days earlier than above).

High calcium, normal manganese : no symptoms.

High calcium, high manganese : older leaves with slight marginal greying and browning; flower stems with trace purple markings, pedicels normal.

Mustard.

Omitting calcium, normal manganese : pH 3.0 and 5.5. Growth normal up to 60 days, middle leaves with marginal and intervenal paling and yellowing, intervenal crinkling, occasional large grey papery intervenal necrotic areas, wilting and collapse of leaves; young leaves occasionally slightly chlorotic and distorted at apex or just behind it; roots grey, and also translucent at pH 3.0 only; general symptoms less marked at pH 5.5.

Omitting calcium, excess manganese : pH 3.0. Growth at first normal at 13.75 and 55 ppm., visibly retarded after 40 and 30 days respectively, severely stunted and checked after 7 days at 220 ppm. and mostly dead after 40–50 days at this concentration.

Mn at 220 ppm. : first symptoms of damage appeared in six days, cotyledons small, not expanding, dark blue-green, yellowing at margins and base, followed by irregular drying out and buff, scorched or necrotic areas; leaves failing to expand or severely distorted at margins and between veins, pale green with intervenal necrosis, wilting and collapse of leaves, chlorosis absent; black spotting of petioles; death of growing point; roots grey or translucent, brown at apex, poorly branched; symptoms observed at 55 ppm. : growth *initially normal, middle leaves later developing slight marginal upward and later downward cupping*, marginal and intervenal paling, becoming limp and drying out to buff necrotic areas; dark brown necrotic lesions in or close to main veins and midrib, causing distortion of intervenal mesophyll, and spreading into brown "central necrosis" type of symptom, along midrib; chlorosis absent; collapse of young leaves and death of growing point; brown spotting of stems in lower regions and petioles; roots grey and translucent but not brown.

Effects at 13 ppm. finally similar but generally less severe necrosis, scorching and distortion.

Omitting calcium, excess manganese pH 5.5. Growth normal at 0.5–55 ppm. for 40–50 days with apparent initial stimulation between 13.75 and 55 ppm. marked stunting visible after 14 days at 220 ppm.

Symptoms at 220 ppm. : severe stunting, young leaves expanding slowly with marginal and intervenal distortion, cupping and paling followed by irregular necrosis and pale brown scorching; severe wilting and collapse of young leaves commencing as greying margin of lamina and finally involving whole leaf and petiole, death of growing point; some plants with chlorosis of young leaves and collapse of older leaves, severe dark brown lesions on petioles and fine spotting particularly lower regions of stems and hypocotyl; roots stunted but not grey or translucent.

Mn at 55 ppm. : symptoms intermediate between 13.75 and 55 ppm. in pH 3.0 series. Symptoms for Mn at 13.75 ppm. correspondingly milder than at pH 3.0.

Plants receiving Mn at 13 and 55 ppm. had produced flower buds when none were evident in the normal manganese series.

Note.—Mustard showed no tendency to recovery from effects of excess manganese.

Swede.

Omitting calcium, high manganese : middle and younger leaves, *intervenal yellow-green, later white mottling, and marked grey or whitish paling margins and forward cupping*, followed by marginal brown necrotic spotting spreading inwards; older leaves becoming mottled yellow-green, and young leaves with marginal cupping and distortion and slight constriction of margin just behind apex; roots brown, and rotting as in omitting calcium.

Note.—Marginal grey paling less marked and defined than in savoy, mottling more general but wilting of lamina (typical of calcium deficiency) not observed.

Red Clover. pH 5.5

Low calcium, normal manganese : no symptoms.

Low calcium, high manganese : yellowing of cotyledons; older leaves, leaflets showing marginal crinkling and *forward curling, slightly cupped*, paling, becoming yellow-green, spreading intervenally, *light brown necrotic spotting, between veins around inner border of pale marginal region*, later intervenal necrotic "hatching" close to midrib and general necrotic spotting; later symptoms, younger leaves (particularly on stems at flowering time) in intervenal crinkling and marginal distortion, *leaflets folded and "hooked" at apex with severe necrosis of margins behind*, pronounced yellow intervenal chlorosis finally becoming general but not persisting late in season, severe brown intervenal necrosis and browning of midrib; flowering stems with sunken purple tinted lesions; flowering accelerated; death of shoots.

High calcium, normal manganese : no symptoms.

High calcium, high manganese : early symptoms resembling above, but less pronounced; considerable recovery after 9 weeks; similar symptoms restored on raising manganese level but advanced symptoms in younger leaves and on stems not observed; flowering slightly hastened (10 days). Lowest level of excess manganese (22.5 ppm.) produced no symptoms

even in low calcium series after several weeks and 41.5 ppm. Mn resulted only in marginal paling and occasional necrosis in high calcium series.

Note.—Chlorotic shoots on plants in the low Ca, high Mn series were dipped in 0.1% FeSO_4 with a wetting agent; the response was irregular, some shoots gave a slight response, others none; on repeating the dip all shoots responded slightly but recovery was not complete.

Sugar Beet. pH 3.0

Low calcium, normal manganese: generally pale, middle leaves with marginal distortion and occasionally brown, necrotic areas around margins and intervenally close to margin, generally recovering, but persisting in one plant, subsequent late season growth stunted with numerous young leaves narrow and elongated with slight marginal paling (mild calcium deficiency).

Low calcium, high manganese: erect habit, growth more vigorous; slightly pale, symptoms generally as above, no marked damage observed even after raising manganese to 660 ppm. but foliage pale, with occasional pale brown marginal scorching, older leaves.

High calcium, low and normal manganese: *leaves thin and remaining limp for about 3 weeks, intervenal crinkling and yellow-green mottling of middle leaves, extreme margins blackening and dark brown necrotic intervenal areas; older leaves dull green, irregular intervenal red or purple blotching becoming necrotic in centre, symptoms persisting at intervals until late in season.*

Normal manganese: older leaves late in season (end of September) slight apical and marginal dark brown scorching suggestive of low K status.

High manganese; foliage pale, and late in season, dark brown scorching of older and middle leaves suggestive of slight potassium deficiency.

pH 5.5

Low calcium, normal manganese: young leaves elongated and paling at margins, 1 plant mild tip hooking characteristic of calcium deficiency.

Low calcium, high manganese: early growth normal, later (September) stunted, generally pale green, narrowing and paling of young leaves, old leaves erect thin, paling intervenally with some irregular marginal brown scorching re-appearing at intervals.

High calcium, normal manganese: old leaves (September) slightly pale with irregular marginal scorching, possibly low potassium symptoms.

High calcium, high manganese: early growth normal, becoming stunted by September, old leaves erect, pale green, pale brown irregular marginal scorch, particularly at higher manganese levels, possibly low potassium status.

Mangold. pH 5.5

Low calcium, normal manganese: growth normal, no symptoms.

Low calcium, high manganese: early growth normal, late in September older leaves erect, with dull grey or whitish diffuse intervenal mottling at 165 and 330 ppm. manganese (not observed at 110 ppm.), no further symptoms on raising manganese to 660 ppm.

High calcium, normal manganese: early growth normal, but older leaves becoming dark green or bronzed, sometimes slight yellowing, later some marginal and slightly intervenal dark brown scorching and collapse of petioles suggestive of low potassium status.

High calcium, high manganese: symptoms as for high Ca, normal Mn but more severe, and particularly so with increase in Mn level from 110 to 330 ppm.; very dark brown scorch, becoming markedly intervenal with forward curling of margins, and collapse of petioles; at highest manganese level (660 ppm.), young leaves abnormally narrow, paling margins, then yellow chlorosis, possibly iron deficiency.

Potato. pH 3.0 and 5.5

Omitting calcium, normal manganese: growth stunted and bushy due to increased number of thin haulms and side shoots; death of growing point and shoot; leaves pale, young leaves with leaflets folded from margins, commencing at apical leaflets; pale or chlorotic just behind tip, necrotic spotting in pale area, later browning, tips blackening and hooking; dark brown markings in veins in pale marginal area, particularly noticeable under surface as blackening in veins near inner border of chlorotic area; youngest leaflets unusually hairy, often remaining folded and withering; stimulation of numerous axillary shoots, shoots yellowing and wilting, brown or black markings on stem at apex of shoot; roots stunted and brown; tubers small and very numerous, severely distorted often much branched, with necrosis and spongy browning of surface, internal brown necrosis of vascular ring in transverse section, or "net" necrosis in surface section, and medullary necrosis in larger tubers.

Note.—Symptoms not materially affected by pH except more stunted, leaf size further reduced, and marginal paling accentuated at pH 3.0.

Omitting calcium, high manganese: General: growth less stunted than normal manganese series; effects of excess manganese more marked at pH 3.0 than 5.5. *Typical calcium deficiency leaf symptoms somewhat modified: paler green, apical leaflets having forward rolling of margins instead of remaining folded and showing pronounced pink tinting behind apex about centre of marginal regions of pale leaflets visible first on undersides: "pseudo primary 'leaf-roll' virus symptoms"; accentuated by progressive increase in manganese level; black necrosis of veins*

on undersides of apical leaflets, and marginal and apical paling followed by browning observed as above but rarer and less marked: *middle leaves with occasional black intervenal markings on upper surface, minute black spotting sparsely on undersides particularly on veins*, main veins on upper side of older leaves show occasional black necrosis; old leaves occasionally wilting and collapsing late in season; (*Mn 165 ppm.*) *black speckling of petioles, then basal parts of stems, rarely fusing into black longitudinal lesions in middle part of stem particularly around leaf bases* but blackening of shoot and black lesions in extreme apex absent; c.f. normal manganese; premature death of plant receiving 165 ppm. after collapse of leaves; tubers resembling omitting calcium type in appearance; stem lesions at pH 5.5 less frequent.

Low calcium, normal manganese: growth thin but not stunted; darker green than above, axillary shoots, and apex of some plants with mild symptoms of calcium deficiency, marginal paling, and scorching, apex leaflets folded; but darkening of stems at shoot apex not observed, tubers larger but frequently deformed, and showing similar symptoms of medullary necrosis or severe necrosis in cortex.

Low calcium, high manganese: growth stunted; leaves slightly larger than omitting-calcium series, general colour medium to dark green, upper leaves with margins of leaflets frequently showing slight forward roll, and faint pink tinting; *early symptoms of excess manganese: black irregular spotting between veins visible on upper surface and commencing in upper leaves*, but becoming general, *black necrosis later becoming concentrated along and finally particularly severe in major veins commencing on upper surface in older leaves* radiating from central region of leaflets, *undersides with profuse minute black spotting on and between veins*; middle and older leaves yellowing with black veins, wilting of petioles and collapse and withering leaves symptoms analogous to "leaf-drop streak virus"; *petioles with profuse fine black spotting fusing into elongated lesions, more severe in older leaves*; *stems with profuse fine black "speckling" on basal part fusing into severe black elongated lesions on middle and upper parts* particularly around leaf base areas but absent from apex; excess manganese effects were markedly and progressively more severe with low calcium than omitting calcium treatments from about two weeks after appearance of symptoms.

Side shoots finally showing slight intervenal chlorosis (*Mn — 82.5 ppm.*) at pH 3.0 but not at 5.5 and in both series *purple-brown necrotic areas on upper surface of leaflet close to midrib in axils of major veins and in smaller areas radiating along major veins, frequently confined to basal part of leaflet and later (end of August) in the upper leaves, extending into the dark green mesophyll in small irregular areas, suggestive of the symptom termed "Central Necrosis"* (see below and section B of appendix). These symptoms were produced with excess manganese at 82.5 ppm. and appeared about a week later in the series at pH 5.5. The plants receiving 165 ppm. manganese were dead; *no central necrosis symptom was observed in the omitting-calcium treatments.*

In general the effect of pH was one of degree of severity of excess manganese symptoms; approximately 50% more manganese was needed to produce similar symptoms at the higher pH, and plants were slightly more stunted at the lower pH.

High calcium, normal manganese: growth normal, colour dark green, leaves largest of any series, generally slightly down-curved apex and margins, suggestive of low potassium status.

High calcium, high manganese: growth normal, slightly paler than above, upper leaves with slight forward rolling of margins, but no tinting; irregular black upper surface spotting absent, necrosis of veins absent at pH 5.5 and rare at pH 3.0; stem and petiole lesions absent, black spotting greatly reduced.

Omitting potassium, normal manganese: growth stunted; typical potassium deficiency leaf spotting followed by marginal scorching older leaves.

Omitting calcium and potassium, normal manganese: growth less stunted, foliage paler green than above, leaves down-curved, finally mild potassium deficiency symptoms (dark spotting undersides) 10 days later than above; no calcium deficiency observed up to 12 weeks.

Omitting potassium, high manganese: growth stunted, foliage dark green *but typical potassium deficiency delayed additional 3 weeks and greatly reduced*; excess manganese blackening chiefly in main veins of older leaves rarely in adjacent mesophyll, fine black spotting on undersides on petioles and stems; stem lesions rare; premature collapse of lower leaves and death of plants before omitting plants; young leaves with mild intervenal yellow-green chlorosis resembling iron deficiency.

Omitting calcium and potassium, high manganese: growth as with normal manganese; foliage medium green; *no symptoms of potassium or calcium deficiency observed*; leaves marked down-curved with backward curling of margins, upper and middle leaves with slight fine black spotting on undersides, *black necrosis of main veins and midrib in central and basal region of leaflets, necrosis spreading for short distance into mesophyll and frequently confined to nearly paired, roughly triangular dark brown or black areas of mesophyll immediately adjacent to midrib and basal parts of major veins and later not always actually in veins*, these symptoms closely resembling field "central necrosis" type but purple tinting absent; necrosis finally spreading out along major veins from midrib in young leaves; middle leaves rapidly dehiscing or limp, prematurely withering and hanging down; upper leaves with intervenal paling basal areas becoming pronounced iron deficiency chlorosis and responding rapidly in 3 days both to spray and in detached shoot placed in 200 ppm. $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ solution; petioles and stems with slight spotting and marked black elongated surface lesions in mid-stem region; N.B. stem lesions were the first symptoms observed in this set; leaf drop leading to premature death of plants.

Tomato. pH 5.5

Omitting calcium, normal manganese : height 35" 21/6/46. Growth ultimately stunted due to death of growing point and die-back of shoot ; young partly expanded leaves (commencing apical leaflet) marginal purpling, central yellow then orange tinting, purple-brown intervenal necrotic areas forming hollow cone-shaped area in middle of leaflet, also adjacent to lateral veins ; younger leaves with leaflets folded, paling at margins and intervenally, and scorching ; old leaves normal ; *occasional blackening on surface of stem from dead apex* for short distance ; roots brown and stunted ; flowers, commencing distal end of truss and particularly younger trusses, withering and falling before setting fruit ; fruit if set, at basal end of lower trusses, frequently developing "blossom end rot" commencing distal fruit ; premature death of plant. Symptoms less severe than in other plants receiving full phosphate supply.

Omitting calcium, high manganese : height 43" 21/6/46 ; less stunted ; calcium deficiency symptoms partially masked, older leaves downwardly directed, leaflets slightly undercurled, colour dull dark green suggestive of low phosphate status ; upper leaves with margins curled up, intervenal distortion, *occasional dark brown necrosis in veins or alongside near leaf tip ; dark speckling in mid stem region with 165 ppm. Mn ; calyx browning at apex of teeth on middle trusses and most severe in distal flowers*, withering and death of young flowers and trusses (older trusses, blossom end rot of distal fruit).

Low calcium, normal manganese : height 35" 21/6/46 ; foliage dark green, and somewhat suggestive of low phosphate status, otherwise no symptoms.

Low calcium, high manganese : height 51" 21/6/46 ; growth tall ; foliage initially as above, leaves long and narrow in outline, middle leaves incurled with marginal scorch, *severe dark brown or black necrosis particularly in major veins*, and adjacent mesophyll, commencing in basal leaflets, *petioles of basal leaflets collapsing and withering*, finally whole leaf involved ; *dark brown irregular slightly sunken lesions on petioles and stems particularly in mid stem region and frequently concentrated around leaf base areas ; apex of stem remaining green ;* severe brown necrosis of calyx commencing distal end of truss or death of flowers and truss from distal end, fruit dehiscing very readily.

High calcium, normal manganese : height 41" 21/6/46 ; appearance suggestive of low P status otherwise no symptoms.

High calcium, high manganese : height 47" 21/6/46 ; general appearance as above, appearance of low P status more marked ; *slight black necrosis in veins, collapse of basal leaflets rare or absent*, stem markings less pronounced ; browning and necrosis of calyx reduced.

Flax.

No effects due to excess manganese were observed.

SECTION B.**FIELD SYMPTOMS OBSERVED IN ACID SOILS—MANGANESE TOXICITY, CALCIUM DEFICIENCY COMPLEX.**

(1) *The "Central Necrosis" symptoms in Potato* observed in plants growing on acid (pH 3.9) unlimed no potash (NP) plots at Sutton Park (see References (9) and (14)):

Growth stunted ; foliage dark green ; upper-middle leaves dull yellow-orange intervenal tint and bronzing apex and margins of apical leaflets, occasionally more or less diffusely in centre of leaflet with dark green margin ; tinting reduced and fading out towards basal leaflets ; and succeeded by progressive increase of "central necrosis" as follows : dark brown necrotic areas approximately one to three-sixteenths of an inch wide adjacent to midrib between main lateral veins in basal central region of leaflet, necrosis in midrib itself rare, necrotic areas frequently roughly triangular and almost paired giving diamond shaped outline ; areas may coalesce to include almost whole of basal area of leaflet including main veins and midrib ; petioles and stems, particularly around leaf bases, with dark brown or black irregular, elongated necrotic lesions in mid-stem region. The central necrosis may frequently appear without the associated purple-bronze or orange tinting even in the apical leaflet.

(2) *The "forward leaf roll" symptom in Potato.*

(a) Growth stunted, habit bushy, growing point "weak" ; foliage usually pale green ; leaflets of young leaves narrow, *rolled forward at margins*, margins sometimes completely overlapping, *marginal paling and frequently pink tinting along margins, stems and occasionally petioles with or without fine black spotting ;* tubers numerous, small and badly shaped.

(b) In cases of extreme acidity these symptoms are modified as follows : growth severely stunted (possibly only 9"), death of growing point ; foliage pale dull green, *leaves small and narrow, leaflets of young leaves small, narrow and folded forward from margins, paling or chlorosis of margins and apex followed by brown necrosis ;* tuber formation is practically nil.

The symptoms noted above may be complicated by symptoms resembling phosphorus deficiency on the middle leaves which appear as an upcurled light brown marginal or intervenal scorching and dull olive-green foliage.

(3) *"Cupping" and leaf-margin symptoms in Brassicae.*

(a) *Cauliflower.* Marked forward "cupping" of leaf margins particularly in middle and

older leaves, initially regular in outline from base to apex of leaf with necrotic spotting and later tearing of margins and perforation of intervenal tissue in advanced stages. Occasionally pronounced cream or white "rim effect." Wilting and collapse of intervenal areas in the centre of the leaf may also occur.

(b) *Savoy*. Slight cupping or concave appearance of expanding leaves; very marked cream or white marginal "rim effect" and some whitish mottling between veins in marginal area.

(c) *Swede*. Leaves tend to be chlorotic and mottled yellow-green followed by grey tinting margins and between veins, finally forward cupping of margins and pale ragged scorching of older leaves.

SOME EFFECTS OF LIME AND FERTILISERS ON POTATOES ON A STRONGLY ACID SOIL AS DETERMINED BY VISUAL SYMPTOMS AND CHEMICAL TESTS.

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When strongly podsolised soils are to be brought under cultivation it is generally necessary to apply generous dressings of lime and manures to obtain satisfactory crops. Such soils may be expected to be deficient in the basic nutrients, calcium, magnesium, potassium and sodium, and often also in phosphorus and nitrogen. In addition, certain mineral elements may be present in toxic amounts, particularly manganese and aluminium.

It is thus of importance to examine the effects of lime and fertiliser treatments on such soils and in particular to see how various treatments affect the mineral status of crops.

An experiment with these objects has been carried out with potatoes on a strongly acid soil reclaimed from heath conditions, with a natural cover consisting mainly of poor grasses.

The results show that on this soil lime treatment is effective in curing calcium deficiency and manganese toxicity, but that after liming, deficiencies of magnesium, potassium, phosphorus and nitrogen may all occur according to the fertiliser treatment given.

Experimental.

The area used for the experiment was a portion of poor heath land, mainly under grass cover, ploughed up for arable cropping in 1944. The soil is a highly podsolised gravelly sand, with pH approximating 4.0, derived from glacial drift consisting mainly of material from the Bunter Pebble Beds.

It was divided into two halves for experimental purposes and these have been cropped alternately with potatoes and sugar beet. The half considered in the present investigation had potatoes in 1944, sugar beet 1945 and potatoes again, variety Majestic, in 1946.

Each half was subdivided in one direction into 10 strips which were given differential liming treatments in the spring of 1944 just prior to the planting of the first crops. The lime strips were crossed at right angles by 8 fertiliser strips, so that there were 80 small plots with different combinations of lime + fertiliser treatment.

The arrangement of the plots and the rates and manner of applying the lime dressings, together with the details of the fertiliser treatments, are shown in Table I.

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TABLE I.
SHOWING LAYOUT ON PLOTS, LIMING AND FERTILISER TREATMENTS.
VIGOUR MARKINGS AND DEFICIENCY SYMPTOMS RECORDED 24/7/46.

Ground Limestone Treatments, 1944.	3 tons Lime on Surface Under	3 Nil	4 —Mg	4 —Mg —N	5 —P	3 —P —Mg	4 Nil	3 —N +Mn	3 Nil
	No Lime	3 Nil	4 —Ca —Mg +Mn	4 —Ca —Mg	3 —P	2 —P	3 —Ca —K* +Mn	3 —Ca —K* +Mn	3 —Ca —Mg
	3 tons Lime on Surface	2 Nil	4 —Mg	4 —Mg —N	3 —P —Mg	3 —P —Mg	4 —K*	3 —K*	3 Nil
	3 tons Lime Ploughed Under	1 Nil	5 —Mg +Mn	4 —Mg	4 —Mg? —P	3 —P	4 —K	3 —K	3 Nil
	No Lime	1 Nil	2 —Ca —Mg +Mn	1 —Mg —N	2 —Ca —P +Mn	1 —Ca —P? —Mg	3 —K* +Mn —Mg	2 —K	1 —K*
	9 tons Lime on Surface Under	1 Nil	4 —Mg	3 —Mg	3 —P —Mg	2 —Mg	2 —K*	2 —K*	2 —K*
	9 tons Lime on Surface	2 Nil	6 —Mg	5 —Mg	3 —P	4 —P —Mg —N	4 —K	2 —K*	1 —Mg
	No Lime	1 —Ca —Mg	3 —Mg	2 —Mg	1 —Ca —P	1 —Ca —P	3 —Ca —K —Mg +Mn	Failure	1 —K +Mn
	9 tons Lime Ploughed Under	2 —Mg	6 —Mg	5 —Mg	4 —Mg —P	3 —Mg —P	4 —K*	2 —K	1 —K*
		9	10	11	12	13	14	15	16
	No Lime	1 —Ca	2 —Ca —Mg +Mn	2 —Ca —Mg +Mn	3 —Ca +Mn	2 —Ca —Mg +Mn	3 —K* +Mn	3 —K +Mn	1 —K* +Mn
		1	2	3	4	5	6	7	8
		Nil	N.P.K.	P.K.	N.K.	K	N.P.	P	Nil

Fertiliser Treatments.

Fertiliser Treatments: N: Nitrogen—Sulphate of Ammonia 3 cwt. per acre.

P: Phosphate—Superphosphate 5 " " "

K: Potash—Muriate of Potash 2½ " " "

Note: Vigour marking (maximum 10) shown on left centre of each square; deficiency or toxicity symptoms on right: (— = deficiency, + = toxicity); * following visual marking denotes no leaf symptoms but deficiency suspected from growth habit. Numbers shown in bottom left corners of two bottom rows of squares are the field plot numbers for comparison with full chemical and tissue test data (see Table II).

The effects of the lime and fertiliser treatments on the mineral status of the potato crop were assessed by visual diagnosis of leaf symptoms on all plots on July 24th, when samples of tops were also taken from 16 plots (one complete series each of unlimed and limed) for tissue tests and full chemical analysis of leaves.

Results.

Table I, in addition to showing the lime and fertiliser treatments, also gives a marking for vigour of haulm (figure in the left centre of each square) and shows deficiency (—) or toxicity (+) symptoms noted. The figures in the bottom left hand corners of the two bottom rows (numbers 1 to 16) are plot numbers for reference in Table II.

Table II presents the results for the full chemical analyses and tissue tests on samples from plots 1—16.

Vigour. The values shown for vigour are on the basis of 10 maximum, so that it will be seen that no treatment produced really vigorous plants. The effects of the various fertiliser treatments can be readily seen from the

than on comparable "no potash" plots, and it may be that potassium affords a protecting effect against manganese toxicity, as has been shown for calcium (1) and which is illustrated in the present data though perhaps complicated by pH changes.

The full chemical data also indicate a poorer soil status for potassium on the side of the area containing plots 8 and 16, a point also shown in the visual data (see Table I).

The main effects of the manurial treatments on the level of the various nutrients are as follows :—

Potassium level is clearly affected by potash manuring in the limed series and the level appears to be lowered by N. P. or P. treatments; magnesium level is decreased by potash manuring and may be increased by phosphorus deficiency; calcium level is lowered by potash manuring; phosphorus level is highest in both series where N. P. K. is applied and, although very low values in the limed series are obtained where phosphates are omitted from the fertiliser (N. K. and K. treatments), abnormally low levels are also shown for P. and Nil treatments in this series; manganese level is possibly only affected by potash fertilisers.

The tissue test data show good agreement with those for full chemical analysis. Thus the differences in calcium and manganese levels between the unlimed and limed plots are clearly shown; for potassium, agreement between the two methods is close; for magnesium, the tissue tests also show the effects of potash manures in depressing the magnesium level; and for phosphorus agreement is also close.

Comparison of Visual and Chemical Data.

Whilst the visual data for the whole of the plots show good general agreement with the lime and fertiliser treatments and with the chemical data, a closer comparison is possible for plots 1—16 from the data given in Table II. Here again it will be seen that agreement is close and there are few discrepancies. Perhaps the main one is for phosphorus on plots 15 and 16 where both chemical methods show low values but the visual method detected only low potassium symptoms; as previously stated, the reason for the low value for phosphorus on plot 15 is not clear.

Discussion.

The results of this investigation showed that on this particular acid soil, reclaimed from heath conditions, deficiencies of calcium, magnesium, potassium, phosphorus and nitrogen and manganese toxicity may all require attention. For the potato crop liming rectified calcium deficiency and manganese toxicity, but further treatment with fertilisers was necessary to obtain appreciable crops. Different fertiliser treatments showed up different deficiencies and they affected the mineral composition of the plants differently. A good balanced N.P.K. fertiliser was not sufficient to overcome all deficiencies and indeed this treatment was associated with a prevalence of magnesium deficiency, which occurred wherever a fertiliser containing potassium was applied. The deficiency of magnesium might be remedied by the use of magnesian limestone instead of the usual calcium types or by including magnesium sulphate in the fertiliser dressing.

It should be pointed out, however, that the problems arising on strongly acid soils may vary considerably and no one method for dealing with mineral element problems can at present be recommended.

Thus at another centre, where various forms of liming materials are being used to correct acid conditions, the use of magnesium-containing limes has resulted in calcium deficiency in mangolds.

Again, at other centres, liming has induced deficiencies of boron and manganese and hence detailed studies for different soils are required. The results reported in this paper show the value of visual and chemical methods, preferably a combination of the two, in investigations of problems of this kind.

SUMMARY.

The effects of liming and of various fertiliser treatments, with and without lime treatment, on the incidence of mineral deficiencies and toxicities in potatoes were examined on a strongly acid soil recently reclaimed from heath conditions.

On the unlimed plots calcium deficiency and manganese toxicity were the main problems, but deficiencies of magnesium, potassium and phosphorus also occurred in association with the different manurial treatments given.

Liming corrected the deficiency of calcium and the toxicity of manganese, but on the limed area it was shown that treatments with fertilisers were necessary to correct deficiencies of magnesium, potassium, phosphorus and nitrogen.

The mineral status of the plants under the various treatments was well shown by visual symptoms and by full chemical analysis and tissue tests, and the results by the three methods showed good agreement.

It is suggested that a combination of the three methods will be valuable in examining problems of crop production on acid soils.

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EXPERIMENTS ON THE CONTROL OF MAGNESIUM DEFICIENCY IN GLASSHOUSE TOMATOES.

IV. CONCLUDING REPORT.

By D. J. D. NICHOLAS and W. R. STANTON.

Experiments on the control of magnesium deficiency in glasshouse tomatoes have been described in previous papers (1, 2, 3). It was shown that a soil application of magnesium sulphate at a minimum rate of 10 cwt. per acre gave a good commercial control and that foliage sprays at the rate of 1% or 2% when applied five times at intervals of three weeks were more effective. It was also established that early foliage sprays delayed the onset of symptoms and that late applications arrested their development.

Although the supremacy of foliage sprays over soil treatment both as regards efficiency of control and economy of material has been demonstrated (1, 2, 3) commercial growers prefer the last-named treatment because of the saving of time and labour. During the 1946 season concluding experiments were designed at the four centres used in 1945, to test whether the inclusion of magnesium sulphate in the routine Shirilan A.G. (anti-*Cladosporium* spray

treatment) would be as effective as the first-named used alone in curing the deficiency. The visual and chemical results suggest that a 2% magnesium sulphate * spray including a spreader such as sulphonated lorol or Estol H, used in conjunction with Shirlan A.G. (2 fluid oz. per 4 gall.) proved as effective as the former when used alone in controlling the deficiency.

EXPERIMENTAL.

Centre I.

The two trials conducted at this centre were designed to study the effects of a soil application of magnesium sulphate at the rate of 20 cwt. per acre with 2% foliage sprays incorporating Shirlan A.G., and applied at intervals during the growing season.

Experiment I.

The house was divided into 4 duplicate plots contained in two blocks A and B, and the following magnesium sulphate treatments were randomised and applied in addition to the N P K base dressing :—(1) Nil, (2) 20 cwt. per acre as a base dressing, (3) 2% foliage spray including Shirlan A.G. at the rate of 2 fluid oz. per 4 gall. of spray.

The soil application was made on 22/2/46 and the house planted with Ailsa Craig two days later.

The foliage spray was made up by dissolving the magnesium sulphate in about 3 gall. of water, then adding the Shirlan A.G. suspended in a pint of water, stirring vigorously, and making up to 4 gallons. Sulphonated Lorol at the rate of 10 oz. per 100 gall. of spray was then added and the mixture well agitated. The foliage spray was applied with a stirrup pump using a three-foot lance with twin fine spray nozzles.

Five sprays were applied at approximate intervals of three weeks throughout the growing season as listed below †.

Date of spray application	Gall. per acre	Lb. $MgSO_4$ per acre	Weather conditions	Damage recorded
2/4/46	150	30	Sunny	Nil
23/4/46	200	40	Sunny	Nil
8/5/46	300	60	Overcast and dull	Trace leaf burn in 6 plants
31/5/46	500	100	Sunny	Nil
31/6/46	800	100	Sunny	Nil

The total quantity of magnesium sulphate used for the five sprays was approximately 3 cwt., which emphasises the economy of material in this spray treatment. The damage recorded as a tip burn in a few leaves occurred when

* The magnesium sulphate used in this experimental series was calcined kieserite ($MgSO_4 \cdot 1H_2O$) originally containing 30% MgO , but at the time of experiment averaging approximately 20% MgO . Growers should use twice the quantities recommended in this paper as commercial epsom salts ($MgSO_4 \cdot 7H_2O$) contains approximately 15% MgO .

† In all experiments described herein trial sprays were applied to a few plants a day before the main application. All sprays should be applied during sunny periods when sprays will dry quickly. This procedure should be adopted by growers who intend using spray treatments as a commercial practice.

the weather was dull, but this was insignificant and no calyx damage was observed.

Observational Data.

The incidence of the deficiency for the three dates is given in Table I. The percentage affected as well as the severity marking are included.

TABLE I.
PERCENTAGES OF MAGNESIUM DEFICIENT PLANTS AND SEVERITY MARKING.

Date	Mg Treatments					
	Control		20 cwt.		2% spray 5 times	
	Block A	Block B	Block A	Block B	Block A	Block B
31/5/46	61 slight- medium	84 medium	35 slight	35 slight	2 trace	1 trace
18/6/46	86 medium	91 medium	58 slight	58 slight	4 trace	5 trace
31/6/46	96 medium	100 medium- severe	60 slight	65 slight	6 trace	8 trace

The soil application of magnesium sulphate has reduced the incidence of the deficiency, but the most effective control resulted from spraying the foliage. The last-named treatment proved more economical in materials as less than 3 cwt. was used for the five foliage sprays as compared with 20 cwt. per acre to the soil. The use of Shirlan A.G. with the magnesium sulphate spray does not appear to affect the efficiency of this control measure.

Chemical Data.

Leaf samples taken from the mid stem portions of the plants were analysed and the results expressed as a percentage MgO in dry matter. The results have been treated statistically and are reported in Table II. The figures represent the mean values of duplicate treatments between which there is no significant difference.

TABLE II.
THE MEAN MgO CONTENT OF TOMATO LEAVES FROM DUPLICATE TREATMENTS.

Date	Mg Treatments		
	Nil	20 cwt.	2% foliage spray and Shirlan A.G.
8/5/46	0.52	0.64	0.88
8/6/46	0.34	0.44	0.84
13/8/46	0.20	0.36	1.10
Treatment Mean	0.35	0.48	0.94

Differences required for significance at .. 5% 1%
 1. Between treatment means 0.08 0.16
 2. Between the values for a given treatment at
 different times 0.19 not significant

The chemical results are in accord with the visual data in showing the superiority of foliage sprays over soil treatment in the correction of the deficiency. At each of the three dates the order of significance is as follows :— 2% spray > 20 cwt. > nil. There is a tendency for the chemical values to fall with season in the nil and 20 cwt. treatments, but there is an increase late in the season in the sprayed plants. The magnesium values in the latter may be too high due to the accumulation of spray residues on the leaf surfaces, but the absence of symptoms relative to other treatments suggests that higher levels occur within the sprayed plants.

Experiment II.

The house was divided into two blocks A and B, each containing five randomised treatments in addition to the general N P K base dressing. The magnesium sulphate treatments were as follows :—(1) Nil : (2) 20 cwt. per acre as a base dressing : (3) 2% foliage sprays applied three times during early season : (4) 2% foliage spray applied once after the appearance of symptoms : (5) 2% foliage sprays applied five times at intervals of approximately three weeks during the season.

Shirlan A.G. was included in the sprays given in Block A but omitted from those of Block B. This afforded an opportunity of comparing the effect if any of the inclusion of Shirlan on the efficacy of the spray treatments in the control of the deficiency.

In contrast to experiment 1 Estol H at the rate of 1 fluid oz. per 4 gall. was used as a spreader.

The soil application was made on 22/2/46 and the house planted with Potentate on 24/2/46.

The spray technique described for the experiment 1 was adopted. Data relating to dates and rates of application, quantities of magnesium sulphate used and spray damage recorded are as follows :—

Date of application	Gall. per acre	Lb. $MgSO_4$ per acre	Weather conditions	Spray damage
23/4/46	100	20	Sunny	Nil
8/5/46	150	30	Overcast dull	Trace leaf burn in 4 plants, calyx and slight fruit damage
31/5/46	200	40	Sunny	Nil
18/6/46	500	100	Sunny	Nil
30/6/46	500	100	Sunny	Nil

Foliage sprays were applied as follows :—treatment (3) on 23/4/46, 8/5/46 and 31/5/46 ; treatment (4) on 18/6/46 ; treatment (5) on the five dates quoted in the above table.

The total quantities of magnesium sulphate used for the season were approximately as follows :—treatments 3 and 4, $\frac{3}{4}$ cwt. per acre each ; treatment 5, $2\frac{1}{2}$ cwt. per acre. The quantities used for foliage sprays are small compared with the soil treatments.

Sunny days are preferable for spraying so that spray droplets do not persist on the leaf surfaces.

Observational Data.

Figures relating to the percentages of plants showing the deficiency as well as the severity marking are given in Table III.

TABLE III.

Date	Mg Treatments									
	Nil		20 cwt.		2% foliage spray 3 times early season		2% foliage spray once at onset of symptoms		2% foliage spray 5 times	
	Block A	Block B	A	B	A	B	A	B	A	B
31/5/46	9 trace	6 trace	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
18/6/46	35 slight	37 slight	2 trace	3 trace	2 trace	3 trace	35 trace to slight	26 trace to slight	Nil	Nil
31/6/46	100 slight- medium	100 slight- medium	40 slight	83 slight	20 trace	15 trace	37 trace	23 trace	Nil	Nil

The visual data suggest that the deficiency is particularly marked in the untreated plots, and that although a soil treatment alleviates this condition it is not as effective as foliage spray treatments. Spraying at intervals of approximately 3 weeks, making a total of five sprays for the season, has effected a complete control, but three early sprays are only effective in delaying the onset of symptoms. A spray applied when visual signs were first observed has arrested their spread. Sprays containing magnesium sulphate and Shirilan (Block A) are as effective as the former used alone (Block B) in the correction of the deficiency.

Chemical Data.

Leaf samples were taken on 31/5/46, 18/6/46 and 31/6/46. The results reported in Table IV represent the mean MgO values for identical treatments in Blocks A and B between which there is no significant difference.

TABLE IV.

THE MEAN MgO CONTENT OF TOMATO LEAVES FROM DUPLICATE TREATMENTS.

Date	Mg Treatments				
	Nil	20 cwt.	2% foliage spray 3 times	2% foliage spray once	2% foliage spray 5 times
31/5/46	0.47	0.68	0.92	0.52	1.03
18/6/46	0.33	0.45	0.48	0.38	0.90
31/6/46	0.21	0.40	0.52	0.57	0.90
Treatment means	0.34	0.51	0.64	0.49	0.94

Differences required for significance at .. 5% 1% points
 1. Between treatment means 0.04 0.05
 2. Between values for a treatment at different
 times 0.11 0.15

Chemical values for the following treatments, 20 cwt., 2% spray 3 times, and 2% spray 5 times are significantly greater than those for the nil plants at

each date. The last-named spray treatment has significantly higher MgO values than any other treatment, and this is in accord with the visual data in emphasising the importance of a continued spray programme to control the deficiency completely. Chemical data confirm the fact that early sprays delay the onset of symptoms and that a late one arrests their development. The absence of significant differences between spray treatments in Block A (including Shirlan) and Block B (no Shirlan) shows that the fungicide does not interfere with the intake of magnesium by the leaves. The Estol H spreader used for this experiment has proved to be as efficient as sulphonated lorol (Experiment 1).

Centre II.

Two experiments conducted at this centre were designed to compare the effects of soil treatment, with foliage sprays which were applied at various times in the season. Results obtained by spraying the foliage with magnesium sulphate plus Shirlan A.G. were compared with those obtained by using the first-named alone.

Experiment I.

The following magnesium sulphate treatments were given in duplicate as well as the grower's base dressing (1) Nil, (2) 20 cwt. per acre as a base dressing, (3) 2% foliage spray applied 3 times at intervals during early season, (4) 2% foliage spray applied once when symptoms were first observed.

Shirlan A.G. at the rate of 2 fluid oz. per 4 gall. was used for one of the duplicate treatments 3 and 4. Estol H was used as the spreader at 1 fluid oz. per 4 gall.

The base dressing was applied on 5/4/46 and the house planted with Vetomold on 26/4/46.

The spray technique described for the previous centre was used. Details of spray applications are as follows:—

Date of application	Gall. per acre	Lb. MgSO ₄ per acre	Weather conditions	Spray damage
13/5/46	200	40	Sunny	Nil
4/6/46	300	60	Sunny	Nil
21/6/46	400	80	Sunny	Nil
9/7/46	500	100	Sunny	Nil

Spray treatments (3) were applied on the first three dates and treatment (4) on 21/6/46. The total quantities of magnesium sulphate used for the season were approximately as follows, treatments (3) $1\frac{3}{4}$ cwt. per acre, (4) $\frac{7}{8}$ cwt. per acre. No spray damage was recorded at this centre as all sprays were applied during sunny weather.

Observational Data.

In Table V the percentage of plants showing visual signs of the deficiency are recorded as well as the severity marking.

TABLE V.
PERCENTAGES OF MAGNESIUM DEFICIENT PLANTS AND SEVERITY MARKING.

Date	Mg Treatments							
	Nil		10 cwt.		2% foliage spray 3 times		2% onset of symp- toms spray once	
	Block A	Block B	A	B	A	B	A	B
4/6/46	4 trace	6 trace	Nil	Nil	Nil	Nil	3 trace	2 trace
21/6/46	20 trace- v. slight	25 v. slight	10 trace	7 trace	Nil	Nil	15 trace	22 trace- v. slight
9/7/46	46 slight	53 slight	26 slight	29 slight	6 trace	3 trace	17 trace	27 trace

The soil treatment has provided a partial control of the deficiency. The three early sprays were more effective but were not adequate to produce a complete control. A spray late in the season, when symptoms were first observed, checked their development. The fungicide which was included in sprays for Block A only, does not appear to have affected the beneficial effects of the magnesium sulphate.

Chemical Data.

The mean values for duplicate treatments appear in Table VI. There is no significant difference between identical treatments.

TABLE VI.
THE MEAN MgO CONTENT OF TOMATO LEAVES FROM DUPLICATE TREATMENTS.

Date	Mg Treatments			
	Nil	10 cwt.	2% foliage spray 3 times	2% foliage spray once (late season)
21/6/46	0.40	0.47	0.96	0.36
9/7/46	0.27	0.39	0.57	0.54
Mean of Treatment	0.33	0.43	0.76	0.45

Difference required for significant difference at 5% and 1%

1. Between treatment means 0.22 Not significant
2. Between treatment at different times Not significant Not significant

Chemical results for plants given three foliage sprays are significantly greater than for other treatments. A late spray has increased the magnesium level in the tissues. There are no significant differences between values in the nil and 10 cwt. soil treatments.

Experiment II.

The house was again divided into two Blocks A and B. The following magnesium sulphate treatments were given to each block in addition to a normal N P K base dressing. Treatments (1) Nil, (2) 20 cwt. per acre as a

base dressing, (3) 2% foliage sprays applied twice during early season as well as a late spray when symptoms appeared, (4) 2% foliage spray applied five times at intervals during the growing season.

Shirlan A.G. was included in sprays applied to Block A only. Estol H was used as a spreader.

The soil dressings were applied on 22/3/46 and the house planted on 24/3/46 with Victory.

Spraying data for this experiment are as under :—

Date of application	Gall. per acre	Lb. $MgSO_4$ per acre	Weather conditions	Spray damage
26/4/46	150	30	Sunny	Nil
17/5/46	200	40	Overcast but occasional bright periods	Nil
4/6/46	400	80	Sunny	Nil
21/6/46	500	100	Sunny	Nil
8/7/46	500	100	Sunny	Nil

Treatment 3 was applied on 26/4/46, 17/5/46 and 21/6/46, and treatment 4 on the five dates given in the table. The total amounts of magnesium sulphate used were approximately $1\frac{1}{2}$ cwt. for treatment 3 and $3\frac{3}{8}$ cwt. for treatment 4.

Observational Data.

The percentage affected and visual marking are listed in Table VI.

TABLE VII.

PERCENTAGES OF MAGNESIUM DEFICIENT PLANTS AND SEVERITY MARKING

Date	Mg Treatments							
	Nil		20 cwt.		2% early foliage spray twice and a late spray		2% foliage spray 5 times	
	Block A	Block B	A	B	A	B	A	B
4/6/46	20 slight-medium	23 slight-medium	5 trace	7 trace	3 trace	Nil	Nil	Nil
21/6/46	46 slight	58 slight-medium	21 slight	24 slight	10 trace	12 v. slight	Nil	Nil
8/7/46	62 slight-medium	68 medium	30 slight	25 medium	15 v. slight	20 v. slight	Nil	3 trace

The visual data confirm results at the previous centre in that spray treatments carried out at intervals throughout the season are more effective than soil application in reducing the incidence of the deficiency. Two early sprays have prevented the development of visual signs until late season and a spray at that stage checked the spread of the symptoms, but a continuous spray programme is necessary to give a complete control. The inclusion of the fungicide has not affected the efficacy of the spray treatment.

Chemical Data.

Leaf analyses were made on 4/6/46 and 8/7/46, using leaves from the mid-stem part of the plants. The mean results for the MgO contents in duplicate treatments are given in Table VIII, as there are no significant differences between the two blocks.

TABLE VIII.
THE MEAN MgO CONTENT OF TOMATO LEAVES FROM DUPLICATE TREATMENTS.

Date	Mg Treatment			
	Nil	20 cwt.	2% twice + 1 late spray	2% 5 times
4/6/46	0.58	0.78	0.89	1.00
8/7/46	0.39	0.45	0.59	0.89
Mean of Treatment	0.48	0.58	0.74	0.94

Differences required for significance at .. 5% and 1%
 1. Between treatment means 0.13 0.19
 2. Between treatment values and times .. Not significant

The order of significance at the first sampling date is 2% 5 times and 2% twice > 20 cwt. > control. At the last sampling time the values for the control and 20 cwt. treated plants are at 0.39 and 0.45 respectively, and are below the threshold of deficiency level, viz. 0.50% MgO. Results for the 2% early spray treatment suggest that the late spray has increased the MgO content above the critical level, and this is confirmed by the visual data. Chemical results for the 2% treatment applied 5 times are significantly higher than for the early sprays followed by a late one, and this is in accord with the incidence of the deficiency. As in previous centres Shirlan A.G. has had no detrimental effect on the intake of magnesium by the leaf tissues.

Centre III.

As in the previous centre this house was divided into two Blocks A and B. The following magnesium sulphate treatments were given in duplicate: (1) Nil, (2) 10 cwt. per acre to the soil, (3) 20 cwt. per acre to the soil, (4) 2% foliage spray three times during the season, (5) 2% foliage spray five times, (6) 1% foliage spray five times.

The soil dressings were given on 25/4/46 and the house planted with Ailsa Craig two days later.

Shirlan A.G. was used in the spray treatments given to Block A but omitted from those of Block B.

The spray dates, rates of application and amounts of magnesium sulphate used were as shown in the table at the top of p. 75.

Treatment 4 was applied on the first three dates. The amounts of magnesium sulphate used for the various spray treatments are as follows:—2% three times, $1\frac{3}{4}$ cwt. per acre; 2% five times, $3\frac{1}{2}$ cwt. per acre; 1% five times, $1\frac{3}{4}$ cwt. per acre. The quantities used for the spray treatments are much smaller than for the soil treatments.

Spray dates	Spray rate	Gall. per acre	Lb. MgSO ₄ per acre	Weather conditions	Spray damage recorded
3/6/46	2%	250	50	Sunny	Nil
	1%		25		
24/6/46	2%	300	60	Sunny	Nil
	1%		30		
12/7/46	2%	400	80	Sunny	Nil
	1%		40		
13/8/46	2%	500	100	Sunny	Nil
	1%		50		
25/8/46	2%	500	100	Sunny	Nil
	1%		50		

Observational Data.

TABLE IX.

Date	Mg Treatments											
	Nil		10 cwt.		20 cwt.		2% 3 times		2% 5 times		1% 5 times	
	Block A	Block B	A	B	A	B	A	B	A	B	A	B
12/7/46	10 trace	22 v. slight	2 trace	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
26/7/46	25 slight	34 slight	14 trace	17 v. slight	5	10	Nil	Nil	Nil	Nil	Nil	Nil
13/8/46	36 slight	42 slight	26 v. slight	30 slight	10	15	5 trace	10 trace	Nil	Nil	3 trace	2 trace
25/8/46	52 medium	63 medium	30 slight	36 medium	20 slight	25 slight	10 v. slight	7 v. slight	Nil	Nil	7 v. slight	8 v. slight

Three 2% sprays during early season have delayed the onset of the symptoms, but it was necessary to apply a total of five sprays to effect a complete control. At this centre a 1% spray appears to be less effective than the 2% rate. No marked difference is evident between the two blocks, although Block A sprays included the fungicide. Symptoms are marked in the nil plot and the soil applications have ameliorated the incidence of the deficiency but not to the same extent as foliage sprays.

Chemical Data.

The mean MgO values for duplicate treatments are given in Table X. There are no significant differences between similar treatments in the two blocks.

- Difference required for significance at .. 5% and 1% levels
1. Between treatment means 0.08 0.10
2. Between the values for a treatment at different times 0.10 0.14

The chemical data show that the MgO content of the leaves are in the following order of significance : 2% 5 times > 2% 3 times and 1% 5 times >

TABLE X.

THE MEAN MgO CONTENT OF TOMATO LEAVES FROM DUPLICATE TREATMENTS.

Date	Mg Treatments					
	Nil	10 cwt.	20 cwt.	2% foliage spray 3 times	2% spray 5 times	1% spray 5 times
24/6/46	0.45	0.52	0.67	0.80	0.95	0.91
13/8/46	0.39	0.44	0.49	0.63	0.92	0.69
25/8/46	0.34	0.43	0.47	0.56	0.86	0.58
Mean of treatment	0.39	0.46	0.54	0.66	0.91	0.73

20 cwt. > 10 cwt. and nil plots. There is no significant difference between 10 cwt. treatment and control plot at this centre. The superiority of a 2% foliage spray applied five times at intervals of approximately 3 weeks during the growing season is again evident. The 1% five times and 2% three times have similar chemical values at the end of the season which are near the threshold of deficiency level, viz. 0.50% MgO.

Centre IV.

A similar trial to that of Centre I Experiment 1 was laid down to compare a soil application at 20 cwt. per acre with a 2% foliage spray applied four times during the season.

The base dressing was applied on 5/4/46 and the house planted on 7/4/46 with E.S.1. The spray treatment given to Block A included the Shirilan A.G., but this was omitted in Block B. Sulphonated lorol was used as a spreader.

Data relating to the four spray treatments are as follows :—

Date of application	Gall. per acre	Lb. MgSO ₄ per acre	Weather conditions	Spray damage
11/4/46	150	30	Sunny	Nil
8/5/46	300	60	Sunny	Nil
31/5/46	400	80	Sunny	Nil
18/6/46	500	100	Sunny	Nil

The total amount of magnesium sulphate used for the four sprays approximates to $2\frac{1}{2}$ cwt. per acre as compared with 20 cwt. in the soil treatment.

Observational Data.

As for other centres the percentage of affected plants was recorded as well as the degree of severity.

It is evident that the soil treatment has reduced the incidence of the deficiency, and the foliage spray either with or without the fungicide gives a complete control.

PERCENTAGES OF MAGNESIUM DEFICIENT PLANTS AND SEVERITY MARKING.

Date	Mg Treatments					
	Nil		20 cwt.		2% foliage spray 5 times	
	Block A	Block B	A	B	A	B
31/5/46	20 medium	25 medium	3 trace	7 trace	Nil	Nil
18/6/46	46 medium -	62 severe	15 slight	18 slight	Nil	Nil

Chemical Data.

Mean MgO results for the same treatments in the two blocks are given in Table XI, as there are no significant differences between duplicate treatments.

TABLE XI.

THE MEAN MgO CONTENT OF TOMATO LEAVES FROM DUPLICATE TREATMENTS.

Date	Mg Treatments		
	Nil	20 cwt.	2% foliage spray 5 times
31/5/46	0.33	0.55	1.10
18/6/46	0.29	0.43	1.10
Mean of treatment	0.31	0.49	1.10

Differences required for significance at .. 5% and 1% point

1. Between treatment means 0.27 Not significant

2. Between values for a treatment at different
times Not significant

Chemical data show that there is a significant difference between foliage spray treatment and soil application. Values for the nil treatment are below the critical deficiency level, viz. 0.50% MgO at the two dates whereas those of 20 cwt. is near the threshold at the second sampling date.

DISCUSSION.

Concluding experiments, made at the four centres used in 1945, were designed (1) to compare the effects of soil applications of magnesium sulphate with foliage sprays, (2) to ascertain the minimum number of sprays required to control the deficiency with special reference to the time of application, (3) to test whether magnesium sulphate when included in the grower's routine fungicide (anti-*Cladosporium*) spray would be as effective as the former when used alone.

Trials at the four centres confirm the previous years' data that a minimum of 10 cwt. per acre of magnesium sulphate (calcined kieserite containing 30% MgO) is necessary for a commercial control of the deficiency. At all centres the 20 cwt. soil treatment has given a better control than 10 cwt. application.

The superiority of foliage spray treatments over soil application both as regards economy of material and efficacy of control confirms the data for 1944

and 1945 (2, 3). The outstanding treatment was the 2% foliage spray applied five times at intervals of approximately two to three weeks during the growing season. In many instances using as little as 3 cwt. per acre of material, this treatment gave a complete control of the deficiency. This suggests that a soil factor is operative in inhibiting the intake of magnesium by the roots.

It is established that early sprays can delay the onset of visual signs and that a spray applied when symptoms first appear can arrest their development. Contrary to previous results it is found that a 2% foliage spray is more effective than a 1% rate when both are applied five times during the season.

At all four centres a comparison was made between spray treatments with and without Shirlan A.G. A spreader was always used with the spray treatments. Visual and chemical data suggest that the fungicide has not affected the intake of magnesium by the leaves and no damage could be attributed to the spray mixture. It appears that when magnesium sulphate is incorporated in the routine fungicide spray it gives a good control of the deficiency as well as retaining fungicidal activity. This result may be important in comparing the relative economic merits of soil versus spray treatments.

Spray injury followed spraying during dull periods but was absent when applied on sunny days. At Centre I some of the flower calyces were slightly damaged after spraying on a dull day, but this had no effect on the development of affected fruitlets. As conditions may vary with location of centres, it is essential to carry out trial sprays on a few plants a day before the main application to discover whether symptoms of leaf injury will develop.

The chemical data for leaves taken from the mid-stem portion of the plants confirm the previous season's suggestion that 0.50% MgO can be accepted as an approximate threshold of deficiency level. The chemical results for sprayed leaves may be too high due to the accumulation of spray residues on leaf surfaces, but the relatively small number affected in such treatments suggest that the high levels actually exist within the plants.

RECOMMENDATIONS.

1. A minimum soil application of 10 cwt. per acre of magnesium sulphate (calcined kieserite 30% MgO) is essential to give a commercial control of the deficiency. The 20 cwt. treatments gave a better control than the 10 cwt. applications during this season.

2. Magnesium sulphate at the rate of 2% can be included in the routine fungicide spray, *e.g.* Shirlan A.G. (4 fluid oz. per 4 gall). In addition a spreader must be included to prevent the spray droplets remaining on the surface of the plants. It is essential to spray at the early growth stage and to continue at approximately fortnightly periods making a total of five sprays.

SUMMARY.

1. Concluding experiments were made at four centres on the control of magnesium deficiency in tomato.

2. A minimum of 10 cwt. per acre of magnesium sulphate (30% MgO) is necessary to alleviate the deficiency and a better control was obtained using 20 cwt. per acre.

3. Foliage sprays were more effective than soil applications, although less material was used.

4. The most effective control was obtained by using a 2% spray five

times at intervals of two or three weeks during the growing season commencing at the early growth stage.

5. Early sprays were useful in delaying the onset of symptoms and late sprays arrested their development.

6. The 1% rate proved less effective than a 2% foliage spray during the current season.

7. The inclusion of a 2% magnesium sulphate in the fungicide spray, *e.g.* Shirilan A.G. (4 fluid oz. per 4 gall.) proved as effective as the magnesium salt used alone in the correction of the deficiency.

8. Risk of spray injury is decreased by spraying on sunny days when quick drying takes place. Trial sprays are recommended before each main application.

9. Chemical data on the mid-stem leaves suggest that 0.50% MgO may be used as a rough dividing line between a sufficiency and a deficiency of the element.

ACKNOWLEDGMENTS.

The authors' thanks are due to Mr. C. F. Mills for assistance with the sampling and chemical analysis of the leaves. The willing co-operation of the growers is gratefully acknowledged.

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THE USE OF GROWTH SUBSTANCES TO INHIBIT THE SPROUTING OF POTATOES IN STORAGE.

By L. C. LUCKWILL.

Introduction.

Experiments carried out at Long Ashton in 1943 (3) had shown that certain plant growth substances, notably alpha-naphthalene acetic acid, were effective in retarding, or, in some cases, completely inhibiting the growth of potato "eyes" when applied to the tubers in solution or as a lanolin paste. Workers in America and Holland (2, 1) have found that the vapour of the methyl ester of alpha-naphthalene acetic acid (hereafter referred to as MANA) is even more active in this respect than the acid itself, and trials were therefore started at Long Ashton to test the effectiveness of this compound under English conditions, and to assess its possible value both to the grower and to the domestic consumer of potatoes. During the year 1945-46 experiments were carried out with potatoes stored in wooden boxes and sacks in a cool barn, and in clamps under field conditions.

Storage in boxes.

Experimental procedure. Medium sized tubers of the variety Majestic, carefully selected for their freedom from disease or blemish, were stored in

wooden fruit boxes loosely lined with brown paper and closed with nailed-on lids. Each box measured 20 x 13 x 7 inches and held 35 lbs. of potatoes. Different boxes received the following treatments, which were designed to compare the varying rates of application and different carriers which had been used by workers in other countries :—

1. Potatoes dusted with 23 gms. of talc which had been impregnated with 0.45 gm. of MANA. This corresponds to 28.8 gm. (approximately 1 oz.) of active substance per ton of potatoes, and is the rate of usage recommended by the Dutch workers. In order to prepare the dusting powder a 1% solution of the methyl ester in acetone was first prepared. This was thoroughly mixed with the requisite amount of talc and the mixture stood in a warm place for 24 hours to drive off the acetone. When dry the powder was again thoroughly mixed before use.
2. Potatoes mixed with 57 gm. of shredded newspaper which had been impregnated with 1.6 gms. of MANA, corresponding to a rate of application of 102 gms. per ton.
3. Potatoes dusted with 0.72 gms. MANA impregnated in 382 gms. of dried soil which had been passed through a 60-mesh sieve. This corresponds to an application of 46 gms. of active substance per ton of tubers. Both this and the previous method have been described by Denny (1).
4. Potatoes dusted with 450 gms. of 0.1% alpha-naphthalene acetic acid in talc, corresponding to a rate of application of 29 gms. of active substance per ton. This was actually a dusting powder prepared for the control of pre-harvest drop in apples and was included in these trials in order to compare the effect of the acid itself with that of its methyl ester.
5. Control—untreated.

The treatments were carried out when the potatoes were put into storage on November 22nd, 1945, and the boxes were not opened until June 13th the following year. This represents a storage period of nearly 7 months which may be regarded as the maximum length of time for which it would normally be required to preserve the tubers. During this period the boxes were stored in a thick-walled stone barn where they were protected both from winter frosts and from summer heat. At the end of the storage period the sprouts were removed from the potatoes in each box and their fresh weight determined. A note was also made of the number of rotten tubers, but owing to the careful selection of tubers for the experiment the losses from disease did not exceed one per box, which was not sufficient to appreciably disturb the results.

Results. It will be observed from the above table that only one of the four treatments resulted in any spectacular diminution in sprouting over the relatively long storage period of this experiment. This was the use of MANA in shredded newspaper at the rate of 102 gm. per ton of potatoes, which reduced the sprouting to the very low value of 6.8% of that of the untreated control boxes (*Fig. 1*). Some retardation of sprouting was also observed when the methyl ester was used at the much lower rate of 29 gm. per ton, but at this rate of application the acid itself had no appreciable effect. That the choice of carrier is of some importance is shown by the comparison of boxes 3 and 1. In the latter the amount of sprouting was 67% of the control, but in box 3, although it contained a much greater quantity of the ester, no inhibition of sprouting was observed. This difference can only be attributed to the difference in the type or quantity of the carrier used, though it is difficult to explain the



Control: untreated

Fig. 1

Treated MANA at 102 gm./ton



Fig. 2

Above | Control clamp, untreated.

Below: Treated MANA at 14 gm./ton in talc.

TABLE I.

RESULTS OF EXPERIMENT WITH POTATOES VAR. MAJESTIC STORED IN CLOSED WOODEN BOXES IN COOL BARN FROM 22/11/45 TILL 13/6/46. EACH BOX CONTAINED 35 LBS. OF POTATOES.

Box No.	Substance used	Rate of application (gm/ton)	Carrier	Proportion by wt., carrier : growth substance	Wt. of sprouts produced per box (oz.)
2	MANA	102	Shredded newspaper	35 : 1	2.4
3	MANA	46	Dried Soil	530 : 1	38.1
1	MANA	29	Talc	50 : 1	23.8
4	ANA	29	Talc	1000 : 1	31.0
5	Control : untreated				35.5

failure of the dried soil method in view of its successful application in America. Possibly the type of soil used is of importance: that used at Long Ashton contained a high clay fraction which may have adversely affected the results.

Storage in sacks.

Experimental procedure. For this experiment potatoes of the variety Red King were used, which had been stored over-winter in a clamp out of doors. The clamp was opened on February 27th 1946, and after sorting out the diseased tubers and removing the few sprouts which had developed, the potatoes were transferred to $\frac{1}{2}$ cwt. sacks. Alternate sacks were treated with 35 gms. of a dusting powder containing 1% MANA, corresponding to a rate of application of 14 gms. of active substance per ton of potatoes. The dusting was carried out by throwing a small quantity of the dust into the sack as each bucketful of potatoes was tipped in, and no attempt was made to secure a uniform distribution of the powder. Altogether 11 half-cwt. sacks were treated in this way and these, together with 11 untreated sacks were removed to a cool barn for storage until required. At weekly intervals between April 23rd and May 28th one treated and one untreated sack were removed for examination, and an estimate of the amount of sprouting was made by removing 50 tubers at random from each sack and finding the number and weight of sprouts on each sample. For this purpose a sprout was defined as any out-growth exceeding 5 mm. in length. The results of this experiment are presented in Table II.

Results. It is evident from the above table that over the comparatively short storage period of this experiment treatment with MANA at the low rate of 14 gm. ($\frac{1}{2}$ oz.) per ton was very effective, the number of sprouts on the treated tubers averaging 22% of those on the untreated controls. On a fresh weight basis the sprouts from the treated lots averaged only 15% of those from the controls. Moreover, it was observed that what sprouts were formed in the treated lots were confined to potatoes lying in contact with the sack, where the concentration of active vapour would presumably be less than in the interior owing to diffusion through the sacking material.

Towards the end of May there was in addition a well marked difference in the quality of the potatoes from the treated and the untreated sacks. The untreated tubers had by this time begun to shrivel and go soft, whereas those

TABLE II.

RESULTS OF EXPERIMENT WITH POTATOES VAR. RED KING STORED IN $\frac{1}{2}$ CWT. SACKS IN COOL BARN. SACKS WERE PLACED IN STORAGE ON 27/2/46, ALTERNATE SACKS BEING TREATED WITH 1% MANA IN TALC AT THE RATE OF 14 GMS. METHYL ESTER PER TON OF POTATOES.

Date	Mean No. Sprouts per tuber		Mean Wt. Sprouts per tuber(gms.)		Mean Wt. per Sprout (gms.)	
	Treated	Untreated	Treated	Untreated	Treated	Untreated
23/4/46	0.96	4.30	0.07	0.70	0.08	0.16
30/4/46	0.76	3.46	0.13	0.65	0.17	0.19
7/5/46	0.60	3.26	0.10	1.16	0.17	0.36
15/5/46	1.10	3.90	0.39	1.39	0.36	0.35
21/5/46	0.80	3.64	0.18	2.22	0.22	0.61
28/5/46	1.04	*	0.32	*	0.31	*

* This sack of potatoes was removed for use in the Station canteen before records had been taken.

stored in the vapour of MANA were still quite firm. Both the treated and untreated tubers were consumed in the Research Station canteen, but no marked differences in cooking quality or flavour were reported.

Storage in clamps.

Experimental procedure. In this experiment 1 ton of potatoes var. Majestic was used, half of this quantity having been sorted by hand and half riddled in a rotary sieve. On March 21st, 1946, these potatoes were put into two small clamps in a field, each clamp containing 5 cwt. of hand-sorted tubers at one end and 5 cwt. of machine-graded tubers at the other, separated by a wall of straw across the middle of the clamp. The potatoes in one of the clamps were dusted with 1% MANA in talc at the rate of 350 gms. of dust per 5 cwt. of tubers (equivalent to 14 gms. MANA/ton), while those in the other clamp were left untreated. The clamps were closed in the usual manner with coverings of straw and earth and were left undisturbed until June 20th, 1946. On this day the clamps were opened and records were taken for each lot of potatoes of (a) the total weight of sprouts and (b) the number of diseased tubers. The results are given in Table III.

TABLE III.

EXPERIMENT ON THE STORAGE OF POTATOES VAR. MAJESTIC IN CLAMP USING MANA AT THE RATE OF 14 GMS. PER TON. TREATMENT CARRIED OUT ON 21/3/46. CLAMPS OPENED ON 20/6/46.

Clamp No.	Treatment and Grading		Original Weight of tubers (lb.)	Weight of sprouts (lb.)	No. of diseased tubers
1	Treated—hand-sorted	.. ..	560	15	32
	Treated—machine-graded	.. ..	560	12	400
	Total—treated	.. ..	1120	27	432
2	Untreated—hand-sorted	.. ..	560	29	31
	Untreated—machine-graded	.. ..	560	28	374
	Total—untreated	.. ..	1120	57	405

Results. On removing the coverings from the clamps the differences between the treated and the untreated lots were immediately apparent (fig. 2). The untreated heaps were covered on the outside with a dense mat of sprouts, averaging 1 to 2 feet in length, which practically obscured the potatoes themselves. There were also some long sprouts on the surface of the treated heap, but these were not nearly so numerous as on the controls. In the interior of the clamps the differences were not so marked, as most of the sprouts both on the treated and control lots, had been shrivelled and blackened as a result of the heat developed in the interior of the clamp. For this reason the weight of sprouts in this experiment is not entirely satisfactory as an index of the amount of sprouting. It is clear, however, that although there had been a considerable reduction of sprouting as a result of the treatment, the rate of application of MANA was not high enough to give anything approaching 100% control over the period of this experiment.

The losses from disease were very high in the machine graded lots, but neither in these nor the hand-sorted lots was there any significant difference between the treated and untreated clamps as regards the number of diseased tubers. There is thus no evidence from this experiment that the presence of growth substance in any way assists or retards the spread of diseases in the clamp.

Discussion.

It is evident from these preliminary trials that it is possible to inhibit the sprouting of potatoes stored in sacks or boxes or in clamps in the field, at least until the middle of June of the year following harvest, by the use of suitable concentrations of methyl-alpha-naphthalene acetate. Neither can there be any doubt as to the desirability of preventing sprouting, since the growth of sprouts represents a serious loss of the stored food material of the tuber, and to the grower who has to desprout the potatoes before sale, it represents also a considerable amount of time and labour. The practicability of applying the treatment on a large scale, however, is bound to be governed by economic considerations—in particular the relation between the price of potatoes, the cost of the labour involved in desprouting, and the cost of treatment. The latter in turn will depend chiefly on the cost of manufacture of the growth substance and the rate of application which is necessary. The cost of manufacture of MANA is difficult to assess accurately, as this compound is not yet produced on a large scale in this country, but it is considered doubtful if it could under present conditions be retailed in a form suitable for application at much under £2 per oz. Regarding the minimum rate of application necessary for effective control of sprouting, the following table, based on results of the experiments described above, will serve as a general guide:—

Potatoes treated in :	For storage until :	Minimum rate of application of MANA	Approximate cost per ton
November	June	3 oz. per ton	£6
February	June	1 oz. per ton	£2
February	May	$\frac{1}{2}$ oz. per ton	£1

Where the potatoes are overwintered in clamps which are not opened until the tubers are required for consumption, the only possible time to apply the treatment is in the autumn when the clamp is being built up. This necessitates a relatively high rate of application to compensate for the loss of active vapour by diffusion out of the clamp during the long storage period, the cost of which would at present be prohibitive.

On the other hand where it is practicable to open the clamps in the spring and to transfer the potatoes to sacks for further storage, those which it is desired to keep until relatively late in the season can be treated effectively with much smaller quantities of growth substance than are required for autumn application, and it is possible that the cost of treating a proportion of the crop in this way would be well justified by the improved quality of the late keeping potatoes. For the domestic consumer who requires to store relatively small quantities in sacks or boxes, a supply of good quality potatoes until the end of the season could be ensured for the outlay of one to two shillings per cwt., and it is possibly to this class of person, rather than to the commercial grower, that the possibilities of the method will appeal most at the present time.

Summary.

1. Preliminary trials have shown that the sprouting of potatoes stored in boxes or sacks in a cool barn, or in field clamps, can be inhibited by the use of methyl ester of alpha-naphthalene acetic acid applied in a suitable "carrier."

2. Both shredded newspaper and talc were found to be satisfactory as "carriers," but no inhibition of sprouting was obtained when dried soil was used as a carrier.

3. The rates of application suggested as suitable range from $\frac{1}{2}$ oz. to 3 ozs. per ton of potatoes depending on the season of treatment and the length of time it is desired to preserve the potatoes.

4. Autumn application, which requires relatively high rates of application, is not at present considered economically feasible, but the cost of treating the potatoes in the spring would probably be justified, especially for the small scale domestic consumer, by the resulting improvement in quality towards the end of the season.

Acknowledgments.

I am indebted to Mr. F. E. Smith, of Pal Chemicals Ltd., and to the N.V. Amsterdamsche Chininefabriek for supplies of methyl-alpha-naphthalene acetate, to Mr. R. L. Steynor for his co-operation and assistance with the field trial and to Miss B. Febrey for help with the experimental work.

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RAIN RESISTANCE OF WINTER WASHES.

By S. H. BENNETT, H. G. H. KEARNS and H. MARTIN.

In their work on the emulsification of high-boiling tar acids for the destruction of potato haulm, Greaves and Mitchell of the D.S.I.R. Chemical Research Laboratory, Teddington, found that emulsions prepared with gum or casein as emulsifier were effective even if the haulm was washed with water immediately after treatment (British Provisional Specification 27902/45). Similarly from twigs dipped in tar oil emulsions and subsequently washed with tap water and allowed to dry, only a trace of tar oil could be recovered when sodium oleate had been used as emulsifier whereas tar oil remained on those treated with a gum-casein emulsion. The rain resistance of the emulsion is clearly of importance for, although no grower or contractor would jeopardise the success of his winter washing by spraying when rain was imminent, a winter wash effective even if rain were to fall before the spray had dried after application would enable spraying to be carried out in weather now thought unfavourable. To test the point trials were made not only of the rain-resistant properties of the gum-casein emulsions but also of tar oils in comparison with D.N.C.-petroleum oil preparations.

Materials.

The gum-casein emulsions were supplied by the Director of the Chemical Research Laboratory and were typical stock emulsion products of the following composition :—

Tar oil emulsion (Teddington) : 60% strained anthracene oil, 0.4% gum arabic, 1.8% casein, 0.866% sodium hydroxide, remainder water ;

D.N.C. emulsion (Teddington) : 60% spindle oil (Shell JD₂) containing one forty-fifth of its weight of dinitro-*ortho*-cresol, 1.0% gum arabic, 0.5% casein, 0.06% sodium hydroxide, remainder water.

For comparative purposes, the following products were used :—

Stock-emulsion tar oil : 2 vol. strained anthracene oil (from a different refiner to that of the oil used in the Teddington product) emulsified with 1 vol. 7.5% sulphite lye (3 vols. syrup 60° TW. to 37 vols. tap water).

Miscible tar oil : a proprietary product conforming to the M. of A. specification (Bull. 122).

D.N.C. product (S. lye) : 2 vol. of the same solution of dinitro-*ortho*-cresol in Shell JD₂ as used for the preparation of the Teddington emulsion, emulsified with 1 vol. 7.5% sulphite lye.

Methods.

The washes were prepared by the dilution of the above products with tap water to yield emulsions containing 0.1% D.N.C. (with 5% by vol. of the petroleum oil) or 3% anthracene oil ; the miscible tar oil was diluted 1 vol. to 19 vols. tap water. Twigs bearing suitable numbers of eggs of either Green Apple aphid (*Aphis pomi*) or winter moth (*Operophtera brumata*) were dipped (26/2/46) into the diluted emulsions for a few moments until completely wetted. Some of the treated twigs were allowed to dry, others after draining for 5 secs. were placed under a stream of gently-running tap water before drying. The dried twigs were then exposed outdoors until just before egg hatch when they were brought back to the laboratory, sampled and placed in suitable

receptacles to await counts of hatched insects and unhatched eggs (see Kearns, Martin and Wilkins (1937), Bennett, Kearns, Martin and Wain (1946)).

For each treatment five replicates were taken for counts. Variations within replicates for each test was determined by the calculation of $(\text{Chi})^2$ but, because of the different numbers of eggs per replicate, the figure for percentage hatch was calculated from the hatched and unhatched totals. The results are assembled in Table I.

TABLE I.

THE HATCH OF EGGS ON TWIGS WASHED AND UNWASHED AFTER SPRAY TREATMENT.

Spray used	Unwashed			Washed		
	Total eggs	% Hatch	$(\text{Chi})^2_5$	Total eggs	% Hatch	$(\text{Chi})^2_5$
On eggs of <i>A. pomi</i> :						
D.N.C. (Teddington)	1926	0.0	—	1637	0.2	7.28
D.N.C. (S. lye)	1054	0.1	1.71	1756	0.0	—
3% Tar oil (Teddington) ..	1378	0.0	—	769	72.6	51.29
3% Tar oil (S. lye)	1086	0.0	—	733	16.1	44.00
5% Miscible tar oil	1085	0.5	4.84	926	79.0	33.16
Untreated (sulphite lye check)	1290	66.4	86.86	—	—	—
On eggs of <i>O. brumata</i> :						
D.N.C. (Teddington)	213	0.0	—	213	8.9	41.89
D.N.C. (S. lye)	418	0.0	—	288	8.7	140.38
3% Tar oil (Teddington) ..	170	41.8	11.10	240	82.9	10.90
3% Tar oil (S. lye)	276	12.3	20.51	142	78.9	4.67
5% Miscible tar oil	185	12.4	29.80	168	51.8	14.79
Untreated (sulphite lye check)	162	86.4	0.42	—	—	—

Results.

The effect of washing the twigs soon after treatment has been to reduce ovidal efficiency to a high degree in the case of the tar oil emulsions, whereas only a slight reduction occurs with the dinitroresol washes irrespective of the emulsifier used. The high kill obtained with the latter wash is indeed surprising in view of the brief interval between treatment and leaching and indicates that the risk, against these pests, of a lowered efficiency by rain following spraying is negligible with the D.N.C. washes. The results do not indicate that the rain resistance of the gum-casein emulsion is greater than either the sulphite lye stock emulsion or the miscible oil, though it should be pointed out that the leaching treatment used was much more drastic than would be likely in field use. The relatively high hatch of eggs of *O. brumata* permitted by the tar oil washes is attributed to the late date of treatment. In other trials it has been found that the efficiency of tar oil washes against eggs of this insect is much reduced by late application.

Summary.

Laboratory trials of the effect of leaching in the ovicidal efficiency of winter washes show that (a) dinitro-*o*-cresol is more resistant to leaching than are tar oils; (b) gum-casein emulsions are not more resistant to leaching than are sulphite lye emulsions.

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A NOTE ON THE ACTION OF METALDEHYDE ON SLUGS.

By A. STRINGER.

It had been suggested that the control of slugs by the use of metaldehyde-bran bait was due to immobilization of the slugs and subsequent exposure to low relative humidity conditions. A simple experiment was carried out to determine the effect of changes of humidity on slugs (*Agriolimax reticulatus* Mull.) affected by metaldehyde.

Slugs were subjected in batches of 20 to each of five treatments, A to E. In treatments A, B, C the slugs were kept in the presence of a bran bait for 16 hours at 95-100% R.H. and 18°C, treatment A being bran; B, 1 gm. metaldehyde in 100 gms. bran; and C, 10 gms. metaldehyde in 100 gms. bran. At the end of the exposure period all the slugs of treatments B and C showed the usual symptoms of metaldehyde "poisoning" and of those which had fed on the 10% metaldehyde-bran 20 out of 40 were dead. For treatments D and E, slugs were placed on glass sheets coated with metaldehyde, deposited from an acetone suspension, at the rate of 1 gm. metaldehyde/sq. ft. The slugs were able to move several inches over the sheets and after 3-4 mins. they had become well covered with metaldehyde, immobilization and excessive secretion of slime having taken place. After an exposure time of 5 minutes the slugs were removed from the sheets, the excess metaldehyde being cleaned off them for treatment D but not for treatment E.

The slugs were then placed in desiccators so that differently treated batches were allowed to recover at relative humidities of 95-100% and 70-75%. There was no mortality in the controls at either humidity, but those at the lower humidity seemed to be a little affected by the drier atmosphere. The slugs which had fed on 1% metaldehyde-bran recovered at the high humidity and died at the lower humidity; the 10% metaldehyde-bran gave a 100% kill at both humidities. The direct application of metaldehyde (D and E) gave kills at both humidities; the kill being greater for 70-75% R.H. than 95-100 R.H.

Where the dosage had obviously been large, as in C and E, the slugs showed a considerable swelling of the body under and anterior to the mantle and in several cases the stomach had been everted through the mouth.

From the tabulated results it is clear that metaldehyde is toxic if the dosage is sufficiently large, and that the dosage required for kill diminishes as

the humidity is lowered. The 1% metaldehyde-bran bait used in the experiment is approximately equivalent to the metaldehyde-bran bait normally used in slug control, and this produces the usual symptoms of immobilization and secretion of slime followed by recovery at high humidities and death at low humidities.

It is concluded that metaldehyde is toxic to slugs, but recovery from a low dosage may take place at a relative humidity of 95–100.

TABLE I.
SUMMARY OF RESULTS.

Temp. = 18°C. 20 slugs used in each test.

Treatment	Exposure time at R.H. (95-100)	Rel. Hum. After Exposure	No. Dead after Recovery Period of		
			0 hrs.	24 hrs.	48 hrs.
A Control	16 hrs.	95–100	0	0	0
„	„	95–100	0	0	0
„	„	70— 75	0	0	0
„	„	70— 75	0	0	0
B 1% Meta-bran bait ..	16 hrs.	95–100	0	0	1
„ ..	„	95–100	0	0	0
„ ..	„	70— 75	0	20	20
C 10% Meta-bran bait ..	16 hrs.	95–100	8	20	20
„ ..	„	70— 75	12	20	20
D 5 mins. exposure on glass sheet	5 mins.	95–100	0	2	3
Coated with Meta. Excess removed	„	70— 75	0	7	13
E do.	5 mins.	95–100	0	16	20
Excess Meta not removed	„	70— 75	0	20	20

A NOTE ON THE RESISTANCE OF *SOLANUM* *POLYADENIUM* TO APHIDS.

By A. STRINGER.

Among the species of *Solanum* recently brought from S. America to provide fresh genic material in potato breeding, is *S. polyadenium* which is known to escape aphid infestation. In discussing this matter with the Scottish workers it was learnt that this freedom from attack is associated either with a repellent action or possibly with a direct insecticidal action. As the latter possibility seemed amenable to chemical examination, tubers of the species, kindly sent by Drs. Cockerham and Black, were planted at Long Ashton.

Attempts were made to infest the plants, in mid-August 1946 with colonies of *Myzus persicae* by placing detached potato leaflets heavily infested with aphids on the plants. After 48 hours the detached leaflets had dried out and

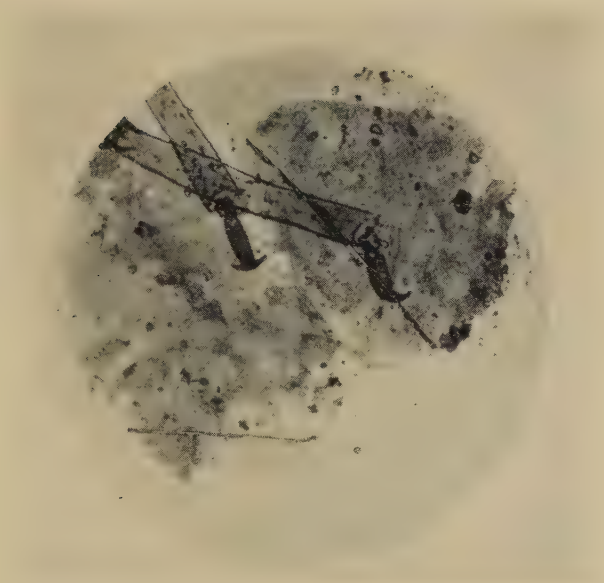


Fig. 1. Accumulation of gummy material on tarsi of *Myzus persicae*
placed on *Solanum polyadenium*.

all the aphids had moved from them to the *S. polyadenium*. The aphids were generally unsettled and moved from leaflet to leaflet, the number gradually diminishing until at the end of six or seven days none remained on the plant. On no occasion was feeding observed, and no aphid exhibited signs of being affected by substances of a toxic nature. The relationship between insect and plant appeared to be such that the insect was unable to feed.

It was noticed that the aphids on the plant accumulated large masses of material around the tarsi as a result of which their movement was much impeded. This black sticky substance cleared when the insects were mounted in Berlese fluid showing the tarsi embedded in a mass of gummy material (Fig. 1 facing p. 88); higher magnification showed the presence of terminal cells of glandular hairs in this gum. This substance could exercise a mechanical effect in preventing the aphid from feeding.

The epidermis of *S. polyadenium* has numerous glandular hairs and tests with Sudan III indicated the presence of a free oily substance on the surface of the leaf.

Adams (1946), working on aphid resistance of potatoes, was unable to infest *S. polyadenium* with *Myzus persicae*. She quotes work by Sleesman on the infestation of *S. polyadenium*, although normally immune, by leaf-hoppers after the plant had been washed with strong soap solution. Adams was able to establish a limited aphid infestation on the stolons, which are apparently free from oil, and suggests that this oil may act as a repellent.

It appears that factors involved in the immunity of mature leaves of *Solanum polyadenium* to aphid attack may be the repellent action of the free oil present on the plant surface and the mechanical effect exerted by the accumulation by the insect of a gummy secretion. These factors result in the aphid being unable to feed.

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THE BEAN SEED FLY, *CHORTOPHILA* *CILICRURA* ROND.

By MARY MILES.

Almost every spring for the past twenty years the maggots of the bean seed fly, *Chortophila cilicrura* Rond., have been reported as injurious to germinating beans in some part of England and Wales, and during 1943--1945 attacks on runner beans were especially severe in the market garden areas of South Worcestershire. The losses caused by the bean seed fly in gardens, allotments and market gardens from North Lancashire to Kent and Cornwall and from Wales to East Anglia have created a demand for control measures, but none could be devised in the absence of knowledge of the pest. This preliminary study of the life cycle and habits of the bean seed fly was undertaken to provide information essential for the understanding of the problem and the development of control measures.

The bean seed fly: a cosmopolitan and omnivorous pest.

The bean seed fly is injurious throughout large areas of the temperate zone of the northern hemisphere. The attacks of the maggots on germinating maize and beans in the United States brought the fly to the notice of economic

entomologists, and by 1922 the list of its host plants included wheat, rye, beet, lettuce, turnip, radish, cucurbits, tomato, cut sets of seed potato, artichoke, asparagus, strawberry, clover, lucerne, tobacco, cotton, onion, garlic, hedge mustard, sweet potato, hemp, larch and orange. In Japan the bean seed fly is a serious pest of germinating rice and flax, and in Russia it attacks germinating cotton and is highly injurious to lupins grown for fodder. In France, Germany and other parts of northern Europe the maggots of the bean seed fly attack germinating cereals and grasses. In north-western United States they attack tree seedlings of oak, peach, red cedar, douglas fir and spruce, and in south-eastern states they are a serious pest of spinach seedlings. This wide range of food plants indicates that maggots of the bean seed fly are able to feed on any available crop. They also feed on organic fertilizers such as cotton seed meal, dried blood and fish meal, and on crop residues buried to provide humus. On occasions they are scavengers, and in North and South America and in parts of Europe, Asia and North Africa they feed in the egg capsules of locusts and play an important part in limiting the numbers of these insects.

Host plants in Britain.

The only host plants of the bean seed fly recorded in Britain are beans and peas, but the regularity with which the maggots have attacked germinating beans in May and the flies have emerged from the infested seedlings in June suggested that the species had other hosts that sustained it during the rest of the year. A search was made in South Worcestershire, where the flies were numerous, to discover other hosts.

Spring Cabbage. A search at the roots of transplanted spring cabbages in September and October revealed numbers of maggots that were identified as those of the bean seed fly. This discovery was of considerable interest. The maggots usually found at the roots of various brassicas are those of the cabbage root fly, *Chortophila brassicae* Bouché, but this species was not found at the roots of cabbages transplanted in autumn and its place was taken by maggots of the bean seed fly. In spring cabbage crops under observation, maggots of the bean seed fly were common and widely distributed, and 1-4 maggots were found in infested plants. The cabbages showed no obvious signs of attack, probably because the number of maggots per plant was low and the relatively high humidity prevented wilting. In 1945 maggots of the bean seed fly fed at the roots of transplanted cabbages until early November.

Other brassicas. Maggots of the bean seed fly were found in company with those of the cabbage root fly at the roots of cabbages, cauliflowers, kale and brussels sprouts during June and July. At this time of the year the maggots of the cabbage root fly outnumbered those of the bean seed fly by about 10 to 1.

Leeks. In late June and early July bean seed flies were seen in numbers on land prepared for leeks and on young leeks after they had been transplanted. On 9th and 25th July random collections of transplanted leeks were examined and maggots of bean seed flies were found to be widely distributed in the crops. As with young spring cabbages, the leeks showed no obvious signs of attack. Infested plants contained 1-5 maggots.

Onions. Adults of the bean seed fly were reared with those of the onion fly, *Hylemyia antiqua* Meig., from cultures of maggots found at the roots of onions. The two species were feeding together, and in the crop under observation maggots of the onion fly were much more numerous.



Damage by the Bean Seed Fly.

Cucumbers. Near Evesham in 1946 the failure of ridge cucumber seeds to become established led to the examination of the crop, and severe injury by maggots of the bean seed fly was discovered. The maggots tunnelled in the hypocotyls of the seedlings and killed them. This type of injury to cucumbers was noted by Petherbridge in the east of England in 1946 and Staniland observed similar injury at Penzance in 1944 (Monthly Summaries of Injurious Insects, Min. Agric.).

Lettuce. The bean seed fly was also bred from the roots of lettuce plants. The crop under observation was seriously attacked by the grubs of mud beetles (*Helophorus* sp.) and maggots of the bean seed fly fed in the roots at the same time.

This first list of host plants suggests that in Britain also the maggots of the bean seed fly feed indiscriminately, and it is expected that further search will extend the host range of the species.

The nature of injury by bean seed fly.

Maggots of the bean seed fly feed within the tissue of the host plant, which they enter below soil level.

Attack on Beans. The maggots invade germinating beans as soon as the growth of the plumule splits the testa. They make shallow, winding tunnels beneath the testa and burrow deeply into the fleshy cotyledons. When only slight tunnelling occurs there is no serious injury to the seedling, but when maggots feed in the embryonic region the seedling is killed. When the maggots tunnel into diseased seeds their feeding seems to encourage decay. In runner beans the cotyledons remain in the soil and may harbour maggots after the seedlings are established, but in dwarf beans the cotyledons are carried above the soil and the feeding tunnels of the maggots show as brown scars and deformities.

The maggots also feed in the shoot (*hypocotyl* of dwarf beans and *epicotyl* of runner beans) and tunnel upwards towards the terminal bud, which may be completely eaten out, and downwards into the radicle, which may then fail to produce rootlets. When several maggots are present the shoot may be completely hollowed, or soft rot may follow the feeding of the maggots and cause the shoot to collapse. Attacked runner beans may have the first pair of leaves aborted and dwarf beans may become blind and snake-headed. The plate opposite shows the nature of attack on runner beans.

Attack on Peas. Injury to germinating peas is similar to that described for beans.

Attack on Spring Cabbages. Maggots of the bean seed fly penetrate the cortex of the main stem of cabbage below soil level and feed in tunnels filled with yellow rotting tissue. The rot did not extend beyond the feeding tunnels in the autumn and it was not possible to continue observations on cabbage crops during the winter. In spring it was observed that crops attacked in the previous autumn contained many plants that failed to heart and others with extensive rotting of the outer leaves. The relationship between intensity of autumn attack by maggots and the condition of the crop at harvest time in the following spring is a matter for further investigation.

Attack on Cucumbers. The maggots tunnel in the hypocotyl of the germinating seeds and kill the seedlings.

Attack on Leeks. Maggots attack transplanted leeks by tunnelling into the white bulb and the tissue around the feeding sites develops soft rots.

Notes on the biology and habits of the bean seed fly.

Although the life history of the bean seed fly has been studied in the United States, Japan and Russia little is known of the fly in Britain. In the northern states of U.S.A. the fly appears to spend the winter in the pupal stage in the soil, but in more southerly states breeding continues through the winter. In South Russia the winter is passed in the larval, pupal and adult stages, and in Japan pupae predominate though flies have been found on warm winter days. Observation in South Worcestershire showed that most of the flies spend the winter as pupae but occasionally a few flies appear to be active in winter sunshine.

At Long Ashton in 1945 and 1946 flies emerged in an outdoor insectary during March and the first half of April. In Worcestershire in 1945 occasional flies were captured in March, but in both 1945 and 1946 they were not seen in numbers until the second week of April. From mid-April until the first week of May they were abundant, and on warm still sunny days they settled in small alert flocks on newly raked soil.

Information on egg-laying is difficult to obtain because the flies rarely mate in captivity. In South Worcestershire egg-laying seemed to take place in the latter half of April on freshly disturbed soil, and a female captured on the bare soil of a bean field on 16th April laid eggs during 19–21st April. The eggs were then seen to be about 1 mm. in length, narrowly elliptical, and glistening white with broken longitudinal ridges. The incubation period is affected by temperature and lasts 1–8 days. The newly hatched maggots wander through the soil in search of food and are able to feed on germinating seeds, young plants, buried crop remains and organic fertilizers. In the autumn of 1945 maggots were seen to reach maturity on cabbage seedlings that had been ploughed in. In 1946 partly grown maggots were first found on germinating beans on 13th May and from that time until the end of the first week of June they were numerous in bean seedlings. On 25th May captive maggots began to leave their feeding sites in beans to become pupae in the soil.

Fully grown larvae of the bean seed fly are rather slender white legless maggots about a quarter of an inch long. The head is vestigial and the body thickens posteriorly. The caudal segment is flattened dorso-ventrally and is extended backwards so that in profile it is somewhat triangular. The posterior spiracles open about the middle of the flattened dorsal area which is surrounded by a corona formed by 5 pairs of papillae. The ventral surface of the caudal segment has 3 pairs of papillae.

Pupation takes place within the puparium formed by the last larval skin, which hardens and turns brown. The caudal papillae of the larva are visible on the puparium and can be used to assist in identification. Puparia are about one-fifth of an inch long. In captivity in 1946 the pupal stage lasted from 25th May to 17th June, a period of 23 days.

Bean seed flies resemble small house flies and are about one-sixth to one-fifth of an inch long. Males are dark greyish brown with the thorax more or less distinctly striped dorsally and the abdomen with a mid-dorsal stripe and faint transverse stripes at the edges of the segments. Females are lighter and more yellowish than males and the dark stripes may be absent or only faintly indicated. Wings are about one-sixth of an inch long and are transparent grey without any trace of yellow on the membrane; the veins are greyish brown. In captivity in 1946 adults of the second generation emerged 17th June to 3rd July with a peak period of emergence during 26th–29th June.

During the same period the flies were captured out of doors on beans, cabbage, leeks, carrots and wild plants on the headlands.

Maggots of the second generation were found at the roots of kale, cabbage and leeks during July, and in captivity the third generation of flies emerged during 3rd–13th August. At this period the flies were again numerous out-doors.

In 1945 a period of warm bright weather in autumn promoted fly activity and bean seed flies were again common in late September and the first half of October. Flies found at this time of the year were considered to be those of a fourth generation. The occurrence of a complete or partial fourth generation of flies is probably usual because in 1944 maggots found feeding in September in transplanted cabbages emerged as flies in November in an outdoor insectary. Some of the flies that emerged in November remained alive outdoors until February and were active in sunshine in spite of hard frost and snow in January.

Annual cycle of generations in South Worcestershire.

Field observations in South Worcestershire suggest that the bean seed fly has 3–4 generations a year, but the generations are not always clearly defined, particularly in late summer and autumn. Flies of the first generation are on the wing from March to early May and give rise to maggots that feed in germinating beans, peas and cucumbers and at the roots of various brassicas. Second generation flies are on the wing from mid-June to early July and produce maggots that feed in leeks and brassicas. Third generation flies begin to emerge early in August and give rise to maggots that feed during August and September in transplanted spring cabbages. In warm weather bean seed flies may be again active in late September and during October, and in 1945 egg-laying took place out of doors during the second week of October. Maggots from this fourth generation of flies fed at the roots of late-planted spring cabbages and in crop residues buried by ploughing. In the field maggots were still active in early November when observations ceased, but those kept in captivity at room temperature reached maturity and pupated during the period 26th October–8th November. In 1944 maggots of bean seed fly were feeding out of doors at the roots of transplanted lettuce as late as 7th December.

The long period of fly activity was further demonstrated by the fact that flies were taken on the wing every month from March to October inclusive, and in 1944–45 individuals were active in an outdoor insectary from November to February inclusive. Maggots have been found feeding throughout the period May to December.

Economic importance of the bean seed fly.

The economic importance of the bean seed fly is difficult to assess, but it is undoubtedly great. Intensive cultivation such as that practised in South Worcestershire has built up high populations of the flies. They select freshly disturbed soil for egg-laying, and in market gardens the rapid succession of crops and almost continuous cultivation of the soil provides ideal conditions for egg-laying throughout the year. The presence of young and succulent crops and the practice of ploughing in crop residues and using heavy dressings of organic fertilizers ensure that the maggots find an abundance of food in the soil. On progressive holdings where irrigation is used to encourage the establishment of transplanted crops and to promote rapid growth most favourable conditions for the survival of root-feeding maggots are created.

The widespread attack of bean seed fly on germinating beans seems to be the result of the coincidence of the preparation of bean seed beds with the period of greatest activity of first generation flies. Peas are less frequently attacked because seed beds are prepared and seeds sown before the flies are active. Cucumber seeds are attacked when the preparation of the beds coincides with the period of fly activity, and attack on brassicas takes place when the transplanting of the crop occurs at a time of fly activity. The direct effect of attack on beans and other seedlings is to delay the establishment of the crop and this may result in lower returns. The effects of attack on transplanted leeks and cabbage have not yet been ascertained. Attacked plants were not killed but cabbage crops attacked by bean seed fly in autumn showed extensive development of soft rots in spring and infested leeks speedily developed soft rot after being lifted. Maggots of the bean seed fly are known to be vectors of soft rot (Leach 1940) and further observations may establish an association between the presence of maggots in cabbage crops in autumn and the development of soft rot in spring, and between the early and hitherto unnoticed attack on leeks and the incidence of disease.

Control of bean seed fly.

Control of bean seed fly has received much attention in North America, Russia and Japan, and the following is a brief summary of some of the measures that have been tried :—

Seed dressings. A wide range of substances including creosote, paraffin, lead arsenate, copper sulphate and calomel dust have been used as protective seed dressings. Seed treatments have not given satisfaction because they tended to injure the seedlings and they failed to give protection when once the testa had split at germination.

Soil dressings. Toxic and repellent substances have been used as soil dressings against bean seed flies. Creosote, phenol, paraffin, carbon bisulphide, cyanide and tobacco dust have all proved useful, but some of these substances may cause injury to the seedlings and others are not suitable for use on a field scale.

Baiting and trapping. Preliminary work on attractants for flies suggest that rhodium oil, sodium borate, yeast, allyl mustard oil and glycine are effective for the bean seed fly, but the effects of systematic trapping of the flies on maggot attack has not been fully studied. In Russia (Rekach 1932) 30–48 per cent. mortality among the maggots was obtained by the use of a poison bait consisting of one part paris green in 25 parts cotton seed meal. The bait was broadcast and harrowed into the soil shortly before seeds were planted.

Indirect control. The following measures have been recommended to reduce loss from attack by bean seed fly : the preparation of seed beds before the flies are active in spring ; delaying seeding until the maggots have finished feeding ; avoiding the use of organic manures, and maintaining a dry tilth to discourage the egg-laying flies.

An experiment in Worcestershire. An attempt was made to repel the flies from a bean seed bed by the use of naphthalene. Flake naphthalene at the rate of $\frac{1}{2}$ cwt. per acre was applied immediately after the seed bed was prepared and again immediately after the ground was harrowed after planting. An adjoining plot was left untreated. The experiment was not sufficiently comprehensive to permit of statistical analysis and it was probable that the repellent effect of the naphthalene extended to the adjoining control plot, but 40 counts of plants on areas of 2 square yards (6 ft. lengths of 3 adjacent bean

rows) on each plot gave an average of 61 per cent. healthy plants on the plot dusted with naphthalene and 53 per cent. healthy plants on the untreated plot.

Reducing loss in bean seed beds. From observations on the bean seed fly in South Worcestershire it appears that some modification in the timing of operations concerned with planting beans would be likely to lessen attack on the germinating seeds. At present the preparation of seed beds and the planting of beans are carried out in the latter half of April at the height of fly activity. If the preparation of land for beans could be timed for March the soil might lose some of its attractiveness for the flies by the time they were ready to lay eggs. Planting beans should be carried out with the least possible disturbance to the soil. The guide marks for planting should be as shallow as possible so as to disturb only dry surface tilth, and harrowing after seeding might be omitted and the ground left without disturbance until the beans were established. In areas where the fly is troublesome the broadcasting of flake naphthalene over bean beds about mid-April is worthy of trial.

* * * * *

A full account of the field observations on the bean seed fly will be published in the *Bulletin of Entomological Research*.

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CHOCOLATE SPOT OF FIELD BEANS IN THE SOUTH WEST.

By L. OGILVIE and M. MUNRO.*

Since the early days of the war there have been poor yields of field beans in most parts of Somerset, Wiltshire and Gloucestershire. The seeds, which are used for cattle feed, have a high protein content, 25% (78% in a digestible form) and any reduction of yield is therefore of great importance. As a result of surveys carried out in the area it has become recognised that the growth of the plants is commonly checked by potash deficiency, phosphate deficiency, waterlogging and frost, but one of the main factors is the disease known as Chocolate Spot. The present paper is a survey of information accumulated in recent years during investigations carried out from Long Ashton Research Station.

Previous Literature. The disease was previously thought to be due to *Bacillus Lathyr* Manns and Taubenh. (10). Sardiña, in Spain, described, in 1929 and 1931 (11, 12), two diseases of the field bean which he ascribed to *Botrytis cinerea* Pers. and *B. Fabae* Sardiña respectively, the latter separated as a new species. *B. Fabae* produced the most virulent symptoms.

In 1933 Itaka (6) described a new species of *Botrytis*, *B. Fabae* Itaka as the causal organism of a Chocolate Spot disease in Japan.

* Dr. H. E. Croxall was associated with the early stages of the work.

Nattrass (8), in 1935, described from Cyprus a similar disease which he proved to be due to a fungus closely similar to *B. Fabae*.

A. R. Wilson (14) carried out at Cambridge from 1932 to 1937 a comprehensive examination of the Chocolate Spot problem. In his opinion the causative fungi in England are mainly forms of *Botrytis cinerea*, although other species, such as *B. Tulipae* Lind., can bring about similar symptoms. He showed that there are two types of infection, "non-aggressive," bringing about localised chocolate-coloured lesions on the leaves, and "aggressive," leading to blackening and death of part or the whole of the shoot system. The main factor in epidemics appeared to be high humidity and rain to maintain a water film on the foliage for some days.

In 1938 (3) El-Helaly described a Chocolate Spot disease of beans from Egypt, which was due to Sardiña's *B. Fabae*.

There has been further literature on the English Chocolate Spot disease, notably papers by Ware and Glasscock (13) in 1941, Moore (7) in 1944, Dillon Weston (1, 2), and Glasscock, Ware and Pizer in 1944 (5).

Geographical Distribution. It is evident that, whatever the species or form of *Botrytis* involved, severe Chocolate Spot symptoms have been recorded from many countries, in particular Great Britain, Spain, Portugal, Morocco, Cyprus, Egypt, Burma, Japan, China, Australia, Bermuda, and probably the United States (see recent references in Review of Applied Mycology).

Symptoms. The symptoms have been well described by Sardiña (11, 12), Wilson (14) and El-Helaly (3). The following description of the non-aggressive stage has been prepared from a typical case by the present writers. The lesions vary from very minute spots to areas 1 cm. or more in diameter, somewhat circular, oval or elongated, with centres Benzo Brown to Deep Brownish Drab or Wood Brown (Ridgway), and margins up to 1 mm. broad, Maroon. The centres are often zonate with elevated circular ridges. The spots, which are usually more numerous on the upper surface, tend to coalesce and involve large areas, especially on older leaves. The lesions occasionally have a greenish yellow (Cosse Green) halo. When many spots coalesce, the constituent ones remain as elevated circles. Reddish brown lesions also become prevalent on the stems. The flowers may become spotted with blackish lesions and shrivel away, before the pods are formed.

Small pods become blackened and killed off, while larger pods develop brownish blemishes. The seeds become spotted with brown.

The Causal Organism. As will be seen from the previous literature recorded above, different species of *Botrytis* have been proved to be the cause of Chocolate Spot in different countries. In particular, *B. Fabae* and *B. cinerea* have been implicated.

As recorded in a short communication (9) published in *Nature*, the writers have come to the conclusion that *Botrytis Fabae* Sardiña is also a common cause of Chocolate Spot of Field and Broad Beans in England, and is certainly the commonest cause of this disease in the South-Western Province.

During 1942, and subsequently, many isolations were made from bean leaves affected with Chocolate Spot and it was noticed immediately that the majority were of a large-spored, small-sclerotial *Botrytis*. Of 32 cultures, only four, all from Somerset, belonged to small-spored large sclerotial forms, falling within the *B. cinerea* range, while the others could be identified as *B. Fabae* Sardiña. Dr. P. H. Gregory, to whom we communicated our findings, writes us that he has had cultures of the small sclerotial form from

Rothamsted Experimental Station (Herts), Sutton Bonington (Salop), Tonbridge (Kent), and Threckingham (Lincs.).

The hyphae are deep brown and granular with an average diameter of 12.7μ . The conidia are borne on minute sterigmata at the slightly swollen ends of branched conidiophores. The conidia of our fungus are ovoid, with the scar of the sterigma well marked. They have a yellowish colour, even at high magnification.

The small sclerotial form has measurements as follows :—

Spores : $13-22 \times 10-16\mu$ (av. $17.4-12.8\mu$).

Sclerotia : $1-3$ mm. in diameter.

The following are measurements of *B. Fabae* according to various authorities :—

Spores :

Sardiña $15.2-24.3 \times 10.9-18.2\mu$ (av. $20-23.1 \times 13.9-16.4\mu$).

Natrass $13-20 \times 9-18\mu$.

El-Helaly $14.5-29.1 \times 11.3-19.4\mu$ (av. $22.5 \times 14.7\mu$).

Sclerotia :

Sardiña $1-3.6 \times 0.9-2.2 \times 0.4-2$ mm.

Natrass $0.5-3 \times 0.4-3.0 \times 0.8$ mm.

(av. $1.7 \times 1.3 \times 0.8$ mm.).

The fungus has never been found by us on non-leguminous plants.

The fungus grows easily on artificial media, such as malt extract agar and potato dextrose agar, and conidia and sclerotia are produced readily.

Pathogenicity of the Fungus.

The results of experiments to test the pathogenicity of isolates of *B. Fabae* and *B. cinerea* were from the first somewhat erratic. Even at suitable temperatures and humidities, as suggested by Wilson and others, comparatively little infection could be got. It was found finally that the best results were to be obtained by growing the beans under conditions of low potash and low phosphate status. Thus in 1945 broad and tick beans were grown in sand and sprayed with spore suspensions of *B. Fabae* and *B. cinerea* respectively, isolated from local outbreaks of Chocolate Spot. Small pin point lesions, later becoming typical Chocolate Spots, were induced by both series of cultures, and especially by those of *B. Fabae*. Reddish streaks were also produced on the stems by the *B. Fabae* cultures but not by those of *B. cinerea*, while the control plants, sprayed with sterile water, remained healthy. Little infection could be obtained on plants growing in soil and a greenhouse compost, and it was found by chemical tissue tests that in the latter cases, both potash and phosphorus were present in much greater amounts than in the sand cultures. Inoculations previously carried out by Dr. Croxall on plants raised under controlled conditions in quartz sand and watered with solutions deficient in these chemicals gave similar results, the plants receiving the full nutrients remaining practically unaffected.

Life Cycle. As already mentioned, brown markings occur on the seeds. In a severely affected crop, many of the pods contain seeds covered with white mycelium and the typical small sclerotia of *B. Fabae*.

On several occasions a large number of seeds have been saved from infected pods. Many of these produced the fungus when incubated in moist

chambers, and pure cultures have been recovered from this source. Affected seeds have also been planted in sterilised soil in pots under conditions of high humidity, and a small percentage of these gave rise to infected shoots which produced abundant spores of *B. Fabae* above the surface of the ground. Similar affected shoots have been seen in the field, as in November 1945, but it is not thought that the carry-over of the fungus in this way is of great practical importance, since affected plants often recover if weather conditions later on are satisfactory.

Again, field trials have been carried out on treatment of infected seeds with organo-mercury seed dressings, but no improvement in germination could be obtained in this way. It is, moreover, difficult to get the ordinary seed dressings to adhere satisfactorily to the seed coats. These results agree with those reported by Dillon Weston (1).

An important source of infection is, in our opinion, old haulms and debris from an infected crop. Such debris was collected in the autumn of 1945, and stored in bins out of doors, and in a dry state in a cool glasshouse during the winter of 1945-46. When brought into the laboratory and incubated under moist conditions it developed abundant spores of the fungus as late as May 21st.

Previous investigators have noticed that small epidemics develop in early spring following injury to the lower leaves by frost. Thus the disease was common in February, 1944. It is, however, usually following rains in early May that the aggressive symptoms described by Wilson become manifest. On the other hand, dry weather during May allows the beans to make satisfactory healthy growth, even despite previous attack, and to set a satisfactory number of pods.

Relation to Location of Fields. The field aspects of the disease have been under close observation by the senior writer for many years. It has been obvious that many fields in the local counties, although in excellent heart, are quite unsuited for bean growing on account of their low lying or sheltered situation, and consequent liability to Chocolate Spot. This is especially the case in the western parts of Somerset. It is noteworthy, however, that even contiguous fields may be different in their reaction, those in the valleys being commonly badly affected, and those on the neighbouring slopes, especially where exposed to the prevailing south-west winds, producing normal crops, even in wet seasons.

Again, more severe Chocolate Spot is commonly found even in the same field in low lying spots or areas sheltered by hedges or buildings.

The disease is most severe in the earliest (late autumn) sowings, probably because of the dense, leafy growth of these plants by the following early summer.

The comparative freedom from disease of bean plants growing in dredge corn has been noticed on many occasions. Thus in 1943 Croxall noted that beans in mixtures of beans, peas, oats and barley were almost entirely free from the disease and carried a good crop of pods, although neighbouring crops were an almost complete failure.

Relation to Plant Nutrition. Previous writers, such as Wilson (14) and others have noted that Chocolate Spot appears to be worse under conditions of unbalanced nutrition, especially where there is deficiency of potash or phosphate.

The symptoms of potash deficiency on broad and field beans have long been known. Briefly the symptoms are these: the plants are very dwarfed,

with internodes short, while the edges of the leaves become scorched and black. In severe cases the lower leaves may fall off. Such plants are more easily injured by winter frosts and the necrotic areas become readily affected by *Botrytis Fabae* and serve as a source of spores. Potash deficiency symptoms were probably confused with Chocolate Spot previous to the war.

In the course of surveys in 1944 potash deficiency was found to be widespread on beans in Somerset, especially as would be expected, where beans were grown after several successive corn crops, or where old pasture, cut for hay, was ploughed up. In addition, such plants appeared to be more susceptible to Chocolate Spot than normal plants. This has been confirmed by chemical tissue tests. Better patches were often observed where hedge trimmings had been ploughed in, and the better response has been confirmed by tissue tests.

Phosphate deficiency characterised by spindly and poor growth and yellowing of the lower leaves was also very prevalent, especially in Wiltshire. The connection between phosphate deficiency and Chocolate Spot was clearly evident. Thus on several occasions parts of fields were more severely affected, and the difference could not be associated with location or drainage. Tissue tests of the leaves from healthy and diseased plants indicated, however, a marked difference in phosphorus levels, the diseased plants having a low phosphorus level while neighbouring healthy plants contained three to five times as much phosphate. This relationship has been verified by means of soil analyses, and by infection of bean plants growing in deficient soils in the greenhouse. The effect of these deficiencies appears to be worse in early sowings than in late sowings.

In common with the observations described above, Glasscock, Ware and Pizer (5) found a highly significant relation between severity of attack and the amount of available phosphorus in the soil as determined by soil analysis. Damage by Chocolate Spot was generally slight on soils containing medium to medium high or higher amounts of available phosphorus, and generally severe on soils containing low amounts of available phosphorus. In trials at Cannington also where $1\frac{1}{4}$ cwt. of muriate of potash had been applied, the plants were much less affected with Chocolate Spot than those receiving $\frac{1}{2}$ cwt.

In general it may be said (as in 1944) that where nutrition appeared to be normal the disease was epidemic in only a few early sown fields on low-lying clay soils.

Control by spraying. Spraying with Bordeaux Mixture was carried out in 1942 in a market garden and in 1943 on farms in Wiltshire. Some control was evident. Thus at Cannington in July, 1944, sprayed plants were 3 ft. 3 in. high and had set 15 pods, while unsprayed plants were 2 ft. 3 in. high, had set 13 pods and were more affected with Chocolate Spot.

Estimates of Loss. Observations made at Cannington Farm Institute in mid-June, 1942, indicated that even in a good part of an infected field half the flowers on the plants, with the developing pods, were killed off by *Botrytis*. In more exposed fields in the neighbourhood about 20% of the flowers were killed off in mid-June.

The amount of loss from Chocolate Spot varies greatly. It is not uncommon for affected crops to be thought useless and ploughed under. Thus in June, 1943, several hundred acres in Somerset were relinquished in this way. By the end of the month it was estimated that potash deficiency, Chocolate Spot and Rust caused at least a 60% reduction of the yield of beans in Gloucestershire and Somerset.

It is usual for Bean Rust (*Uromyces Fabae*) to supervene during July, in conjunction with infestation by the Bean Aphis (*Aphis Fabae*), the latter being subsequently controlled effectively by Hymenopterous parasites. Syrphid flies and ladybird beetles, but the pods by that time have become partly filled, and the effect is to interfere with the maturation of the crop.

Control Measures. It is evident to the writers that in most years bean-growing in Somerset is attended with risk and we would suggest the following measures:—1. Choosing, where at all possible, fields which are on a slope or well exposed to the prevailing wind. Where this is impossible, alleyways might be left running through the fields in the direction of the prevailing wind to promote rapid drying after rain.

2. Seeing that the plants are well supplied with potash and phosphates.

As a long-term policy, the selection of plants apparently somewhat resistant to Chocolate Spot would probably be worth while.

ACKNOWLEDGMENT.

We are indebted to Dr. Nicholas for carrying out and interpreting chemical tissue tests.

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PROGRESS REPORT ON HOP DISEASE INVESTIGATIONS IN THE WEST MIDLANDS.

By E. H. WILKINSON.

Introduction.

This report summarises the information obtained from extensive field observations of hop diseases in the West Midlands and also includes certain results obtained from experimental work carried out in this area and at Long Ashton. The major part of this experimental work was, however, still at an unfinished stage in 1946 and consequently is not dealt with in this brief article.

The diseases causing the greatest concern in the West Midlands are of the

virus or suspected virus type known as Mosaic, Nettlehead, Split-leaf Blotch, Chlorotic disease and Small hop disease. In Kent these diseases also cause serious annual losses to hop growers, but the attack by the progressive and fluctuating forms of Verticillium Wilt is, at the present, the main problem facing the South-Eastern growers. During the past four years the mild form (fluctuating) of Verticillium Wilt has been found in the West Midlands, but as far as the writer is aware, no single cause of the serious (progressive) form has come to light.

Mosaic.

Mosaic has now become so prevalent in the Golding growing areas of the West Midlands (*e.g.* the Teme Valley) that many growers have been forced to replace the choice, but mosaic-sensitive, varieties of the Golding group by the coarser but mosaic-tolerant Fuggle. In one or two instances growers are considering the replacement of their Goldings by certain of the mosaic-tolerant Wye Seedlings bred by Prof. E. S. Salmon.

Experimentally the disease can be transmitted by grafting, but no evidence is available that this can be done by leaf rubbing or sap inoculation. The method of natural spread is not known but insect transmission is strongly suspected.

Experiment on hot-water treatment. In an experiment laid down in spring 1945, cuttings of the mosaic-tolerant Brewer's Gold were hot-water treated at a range of temperatures between 31° and 48° C. for periods from 15 min. to 4 hr. A bine from each treated cutting was then inarched to a plant of a mosaic-sensitive variety. All the treated cuttings transmitted mosaic symptoms, indicating that the hot-water treatment failed to inactivate the virus.

Recommendations for field control. As it is known that the spread of mosaic is promoted by the planting of diseased cuttings, planting of mosaic-tolerant varieties in close proximity to Golding yards and the introduction of virus-tolerant male hops within the yards, the following recommendations are made:—

(i) Cuttings or one year old roots (bedded sets) should be obtained from a disease-free clonal stock or from a commercial yard known to be free of mosaic.

(ii) Golding yards should be set as far as possible from tolerant varieties such as the Fuggle and Wye Seedlings.

(iii) Only sensitive males should be planted within the yard.

(iv) Inspection of hopyards should be frequent and thorough. All plants showing symptoms of mosaic should be grubbed and burnt. If a few isolated stocks only are found it is a wise precaution to grub not only the infected plants but also the two stocks adjoining.

Nettlehead.

During the past 3—4 years, the rate of spread of Nettlehead in the West Midlands has caused concern to many growers. Unlike Mosaic, which develops only in the Goldings, Nettlehead attacks all varieties, and male hops have also been seen showing well developed symptoms. Extensive surveys show that the majority of diseased areas occur round the margins of yards in close proximity to hedgerows and trees, thus suggesting that certain hedgerow plants might act as symptomless carriers of the virus.

Experimentally Nettlehead can be transmitted by grafting, but failure resulted after tests involving leaf rubbing and sap inoculations.

A preliminary survey in 1945 suggested a possible correlation between incidence of disease and poor, shallow soil conditions. A detailed survey of soil conditions in relation to nettlehead was subsequently made by Mr. J. A. H. Tolhurst, whose results are given on pp. 105-112.

Split Leaf Blotch.

This disease was first recorded in 1928 in a form to which the name Split Leaf was given. During 1931-34, however, the disease developed an aggravated form in which oily patches appeared on the infected leaves. This is the phase known as Split Leaf Blotch. In field observations in the West Midlands started in 1943 the Split Leaf form was not found, all infected plants showing Split Leaf Blotch. Fuggles appear to contract the complaint more readily than Golding varieties and in many instances the general vigour of the yard was seriously affected. Goldings and Golding varieties show the disease, but in these the effect is of minor importance.

No Fuggle yard was seen totally free from the disease, many showing an infection up to 75% of the plants. In some plants one or two leaves only are infected causing very little or no check to the growth of the bines but, at the other extreme, some stocks show a complete infection, with all leaves severely split and distorted. In such cases the check to growth is considerable and frequently prevents the bines from reaching the top wire by the end of the season. The hop-bearing laterals are short and bear a greatly reduced crop.

In Fuggle yards young replants have frequently been seen infected with the disease, and there appears to be little doubt that such plants have originated from cuttings taken from a parent plant already infected with Split Leaf Blotch.

Development of symptoms. Detailed observations of the development* of Split Leaf Blotch symptoms were made during 1944 in selected Fuggle yards in the Teme Valley.

The first symptoms appear during the first week in June, when the bines are from 8-10 feet high, on the leaves just below the bine apex downwards to those at the 3-4 foot level. The lamina of the young, half-expanded leaves showed a oil-like transparency except for an outer green band involving the leaf serrations. Within a few days these have developed typical oily patches usually in the centre or quite frequently at the indentations between the lobes. Later the oily patches dried out, contracted and turned a darker brown, so causing an intense puckering or distortion of the affected leaves. Where the oily patches occurred on the leaf margin a similar behaviour was observed, but one lobe normally curled over so forming the "parrot-beak" appearance.

Effect of disease on vigour of bines. Observations made during 1944 on specially marked stocks in certain Fuggle yards indicated that the average height of bines from healthy plants was $2\frac{1}{2}$ feet greater than that of bines from stocks infected with Split Leaf Blotch. Measurements were made of the bines until they reached the top wire some time during late June.

Relation between "spidery hop" and Split Leaf Blotch. When a normal healthy hop plant is "cut" in early spring numerous buds develop on the crown of the rootstock, each one capable of forming a single bine. By late April or early May these bines vary in length from a few inches to three feet and with their leaves form a mass of growth which is bushy in appearance. Certain hop plants, however, when treated in the same way produce a few bines which are "spidery" and weak in growth.

Many Fuggle yards when examined at the end of April showed a mixture

of bushy and spidery stocks. It was decided that certain of these yards should be examined in detail in April and that each stock should be recorded as being in one of the two categories mentioned. These yards were then mapped for the presence of Split Leaf Blotch in August. The majority of the plants recorded as infected with Split Leaf Blotch in August coincide with those stocks showing spidery growth in the spring, whereas the majority of those which showed bushy, healthy growth in April were free from Split Leaf Blotch in August.

The results obtained from these observations suggest that the presence of Split Leaf Blotch in a hop plant induces weak, spidery growth early in the season, this weakness being observed and reflected in the type of growth produced during the remainder of the season.

Cuttings infected with Split Leaf Blotch. Individual bines (var. Fuggle) infected with Split Leaf Blotch in August 1943 were marked and the cuttings therefrom collected in March 1944. A hundred of these cuttings were planted out with an equivalent number of East Malling clonal Fuggles at the same time and in the same soil and allowed to take root. During June a count of the "take" was made as follows:—

Cuttings obtained from bines infected with Split Leaf Blotch	= 66%
" " "	E. Malling Fuggles = 100%

This result suggests that cuttings infected with Split Leaf Blotch are weaker than those taken from healthy stock and will not root so readily.

All those infected cuttings which survived produced typical Split Leaf Blotch symptoms in June and July, whereas the plants produced from the clonal material remained free of the disease, thus indicating that Split Leaf Blotch is capable of being spread by means of infected cuttings.

Grafting experiment. A grafting experiment was carried out at Newnham Bridge in 1944 and 1945 when hop cuttings taken from Fuggle plants showing severe Split Leaf Blotch were grafted to healthy Malling clonal Fuggles in May—June 1944, an equivalent number of the latter being left as controls. No symptoms of the disease were observed in the test or control plants during that season.

In 1945 the vines from the experimental plants were trained up 11-foot wirework and on June 2nd characteristic leaf symptoms of Split Leaf Blotch were seen to have developed on a number of test plants. The following results were recorded:—

Test plants.

No. inarched to Split Leaf Blotch infected Fuggles	=	22
No. showing symptoms of Split Leaf Blotch	=	12
No. still healthy	=	8
No. dead (1944-5)	=	2

Control plants.

Total No. present	=	22
No. showing symptoms of Split Leaf Blotch	=	3
No. healthy	=	18

These results suggest that Split Leaf Blotch is graft transmissible and is therefore most likely to be virus in nature.

Three of the control plants (*i.e.* those not inarched to diseased plants) developed symptoms of the disease during the second season. Since all 22

controls were each planted 18 in. distance from an infected plant and remained in such close proximity for one complete season (1944) it can be argued that, provided that Split Leaf Blotch is a virus disease, these three plants became infected by natural means.

Chlorotic Disease.

This was first recorded in 1927 in a West Midland hop yard. In 1945 two new cases were seen and four more in 1946, one of these involving some 140 plants.

The confirmation of four new cases of the disease in the West Midlands during 1946 may be coincidental, yet, on the other hand, it might suggest that this virus disease of the hop is on the increase. As Salmon and Ware carried out successful experimental transmissions by leaf-rubbing and sap inoculation it would be natural to assume that the disease might be expected to spread rapidly in the field. Observations carried out over a period of three years suggest that this is not so or, at the most, spread is very slow.

The disease breaks out anywhere in old-established hop yards, and it is difficult to find an explanation for its appearance other than the possibility of an insect vector the identity of which is as yet unknown.

Small Hop Disease.

One instance only of this disease has been observed in the West Midlands. This occurred as a single stock of the variety Mathon. Attempts to investigate the transmission of this disorder by grafting experiments have hitherto failed because the infected cuttings failed to root on all occasions in the experimental plot.

Discussion.

Each year West Midland hop growers face serious losses due to the attack of the virus or suspected virus disease discussed briefly in this article. In the case of Mosaic and Nettlehead constant and thorough examination of the yards for diseased plants and their subsequent removal is the only method by which the diseases can be prevented from doing still more serious damage. In the case of Split Leaf Blotch no grubbing of individual plants is carried out, but if it were possible to assess the loss of crop involved each year by individual growers as the result of general weakness of stock caused by the presence of this disease it would be found to be considerable.

The general availability to all growers of disease free, true-to-type stock would go a long way to reduce the incidence of all the virus disease but, at the same time, it is essential that more should be known concerning the mechanism of natural spread of these diseases within the yards. Certain investigations have been attempted to find a possible insect vector or vectors, but so far negative results have resulted. From the writer's experience this would seem to be the most profitable line of research to pursue, although it is quite possible that in order to obtain positive results very exacting host-vector experiments will have to be made under closely controlled conditions.

Acknowledgment.

This work has been carried out with the aid of a grant from the Agricultural Research Council.

SOIL CONDITIONS IN RELATION TO NETTLEHEAD OF HOPS IN THE WEST MIDLANDS.

PROGRESS REPORT, 1946.

By J. A. H. TOLHURST.

This investigation had two aims : (1) to determine the extent to which the incidence of nettlehead could be related to soil type ; (2) to examine the relation between nettlehead and the nutritional status of the hop plant. In this preliminary survey the distribution of nettlehead and of the soil types was studied in detail in eight hop yards, and in two others soil profiles only were examined. All were near Hereford and on the Old Red Sandstone, although the two last-named yards showed some Silurian influence.

EXPERIMENTAL METHODS.

Soil Examination :

Soil profile maps were prepared for all the yards, and profile samples, representative of the soil types, taken for future analysis. For this survey, auger borings were made at regular intervals over the yards, using the lay-out of the rows and poles as the basis. Distances between borings were decided on arbitrarily, and were occasionally altered in those areas where the size of the soil type unit seemed to warrant such a change. Very rarely were borings made with reference to nettlehead outbreaks, and where this was so, the borings were always additional to the normal plan.

Mapping of Nettlehead :

Seven yards were mapped accurately by the team, under the guidance of Dr. E. H. Wilkinson. Nettlehead, grubbed, replanted, and male hops were noted and their precise positions later plotted on maps which recorded the lay-out of rows and poles. Thus it will be possible to enter on these maps the spread of nettlehead in subsequent years.

The eighth yard was so severely attacked that an approximate marking, by small areas, was considered sufficient. Time did not permit the marking of the two remaining yards.

When marking for nettlehead three symptoms on the leaves were given most importance, namely, clearing of the veins, up-curling of the edges, and a dark, varnished appearance. Hot weather caused some symptoms to be masked in summer, and many stocks previously noticed as showing nettlehead had to be recorded as healthy. Only definite nettlehead attacks were accepted, as split leaf blotch was also scattered over all the yards. Fuggles was the only variety studied, and no complication from mosaic arose.

Nutritional Status of Hops :

Leaf samples were collected at three times during the summer, June 27th, July 31st and August 28th. At the first sampling, leaves were taken from a point about two-thirds up the bine, but at the later samplings they were taken at a height of about seven feet from the ground. This was convenient, and also eliminated any possibility of senescence of the leaf.

Samples were chosen, wherever possible, from healthy and diseased stocks on each soil type in the yards. The usual precautions were taken concerning contamination and physiological comparability.

The petioles were used immediately for tissue tests in an attempt to obtain a quick estimate of the contents of nitrate nitrogen, phosphate, potassium, calcium and magnesium. The laminae were dried and prepared for full chemical analysis.

Correlation of Soil and Disease Data :

Since the soil profile and nettlehead maps were drawn on the same basis, it is possible to superimpose the soil map on the corresponding disease map. In this way the percentage of diseased stocks, including grubs and replants, has been estimated by counting for each soil type.

It should be appreciated that the soil map can only be approximately delineated, while the disease map is accurate, and that while the great majority of grubbed stocks had nettlehead, there may locally have been other reasons for their removal.

RESULTS (1) SOIL DATA.

Description of Soil Types.

The following brief notes are taken from detailed profile descriptions, and are intended to bring out the salient points by which each type may be distinguished in the field. No chemical data are available.

The parent material in the majority is the Red Marl phase of the Old Red Sandstone. This may be overlain by mica beds or sandstone, as in types 1 and 1a. Types 8 and 8a are peculiar in this respect, and the parent material is described under their sections.

In general the surface layers are very similar, apparently being fairly low in organic matter and stones, excepting the stony profile of type 8a.

Type 1. Reddish-brown silty medium loam merging into a micaceous layer over the Red Marl. Mica is often present in quantity, giving this layer a characteristic feel and glistening appearance. Below the spongy mica there is usually a dark reddish-brown partially indurated micaceous sandstone. Mica usually appears between 20 and 30 inches depth, and the Red Marl below 27 inches.

This type covers large areas in many yards.

Type 1a. Similar to Type 1, but here a sandstone layer occurs at depths of from 12 to 27 inches. The surface layers are sandier and a richer red-brown colour. Usually the sandstone layer is chocolate-brown, indurated and very difficult to penetrate, 1-12 inches thick, and containing a moderate proportion of mica. The profile is drier than Type 1, and the change from the upper layers to the indurated layer is sharp. Organic matter would appear to be low.

This type does not cover very large areas, but is nearly always adjacent to type 1 and may often merge into it.

Type 2. Medium-brown, medium to heavy fine sandy silty loam, showing very slight gleying below about 15 inches. At this depth large nodules of manganese oxides are very frequent. Merges fairly gradually into the Red Marl at depths greater than 27 inches. This type is really a moist variation of type 4 (Bromyard medium loam) and occurs very commonly in low-lying areas of most yards.

Type 3a. A wetter stage than type 2. Type 3a has a yellow-brown layer of heavy silty loam, with a few manganese nodules, occurring at about 15 inches and merging into Red Marl below 30 inches.

Type 3, which is mapped with 3a, is a still wetter stage. Here there is a yellowish layer of silty heavy loam which is often sticky, and probably high in clay. It does not continue down to the Red Marl, but is only a few inches thick, and the remainder of the profile is similar to 3a.

This type is only important in yards with very low lying areas.

Type 4. The Bromyard type of reddish-brown fine sandy silty medium loam. The profile is compact, as are the two previous types, and merges very gradually into the Red Marl. An arbitrary distinction from the following type is that type 4 is taken to have not less than 18 inches depth of soil over the Red Marl, but the usual depth is over 30 inches.

The most widespread type found in the survey.

Type 4a. The Shallow Bromyard Series. Since the Red Marl occurs at less than 18 inches depth, the surface layers are usually dry and open. These layers may vary somewhat, but the depth of the marl is the dominating feature.

This type occurs in most yards, and although not in large areas its relation to elevations in the ground level makes it important.

Type 5. This is a rare type and not important. It is uniform throughout, and is highly silty and a little laminated. Depth is over 30 inches.

Type 6. Reddish-brown fine sandy medium loam. A variation of type 4, being higher in fine sand content. Fine sand increases with depth, to Red Marl below 30 inches. The profile is quite uniform, compact, and coarser to the feel. It is drier than type 4 and more open in structure. A type occurring in a few small areas only.

Type 7. Very similar to the above, the main differences being the yellow-brown colour, and the absence of a coarse feel. Fine sand is apparently higher in the surface layers than in the lower.

Again only of local importance in a few yards.

Type 8. Here the parent material suggests a transition to the Crustone phase of the Old Red Sandstone. The Marl is starchy in appearance and very sticky when wet, and the bright red colour is not present, greys, greens and blues being plentifully mixed with orange brown.

The whole profile shows this influence, and the brown silty heavy loam becomes sticky, and often waterlogged, before merging into the parent material at a depth of about 30 inches. The only other feature of interest is the occasional occurrence of stones in the surface layer, similar to those found in the following type.

Only one yard has shown this type, over a large area.

Type 8a. The surface layers are similar to type 8, but the quantity of angular, blue shaly stones increases until a solid rock of this material is met at about 20 inches. The rock layer is absolutely impenetrable. It is non-calcareous.

Again, this type has only been found in the one yard, associated with type 8, over a fairly large area.

Soil and Disease Relationships.

Table I gives the distribution of Nettlehead on the various soil types in the yards for which data are available.

TABLE I.
DISEASE IN RELATION TO SOIL TYPE.
NETTLEHEAD EXPRESSED AS A PERCENTAGE OF TOTAL STOCKS.

	Centre 1	Centre 2		Centre 3	
	Yard 2	Yard 1 (part of)	Yard 2	Yard 1	Yard 2
Solid type					
1	4.9	—	4.0	9.6	—
1a	4.9	—	—	11.2	—
2	4.6	7.8	0	10.0	17.5
3 & 3a	6.0	15.3	—	5.9	—
4	1.7	15.5	0.8	6.9	8.0
4a	24.4	11.1	12.4	10.6	7.3
5	15.4	—	0	0	—
6	10.5	—	—	3.3	—
7	—	—	—	5.5	—
8	—	—	—	—	9.5
8a	—	—	—	—	8.6

(A dash indicates that the soil type does not occur in the yard.)

Data from certain mapped yards is not included in Table I, for the following reasons:—

Yard 3 of Centre 1 had one half replanted in 1946, and grubbing of the remainder was so intensive prior to replanting that representative records were not obtained.

(Yard 1 of Centre 2 also had the worse half replanted in 1946, but here the remainder can be considered a separate unit).

A considerable portion of Yard 1 of Centre 1 was completely grubbed in 1946, the grubbed region being almost entirely confined to soil types 1 and 1a. Large areas of soil types 2, 3 and 4, however, lay outside the main grubbed block. The percentages of Nettlehead on these three types were:

Soil type 2, 0.3%; Soil type, 3, 0.5%; Soil type 4, 0.4%.

In Table II, the disease percentage for each soil type is expressed as an average for all the yards, and the three figures given for Yard 1 Centre 1 are included in computing the averages in the second column. As this yard included 83,000 stocks, counts from this area have a profound influence on the over-all percentage figures.

TABLE II.
AVERAGE DISEASE PERCENTAGE IN RELATION TO SOIL TYPE.

Soil Type	Percentage, excluding Yard 1, Centre 1	Including Yard 1, Centre 1
1	6.1 (2,000)	No change
1a	5.8 (1,200)	"
2	6.8 (3,800)	1.4 (20,900)
3 & 3a	11.0 (650)	1.1 (10,300)
4	4.0 (31,100)	2.5 (52,000)
4a	10.7 (3,200)	No change
5	5.6 (38)	"
6	9.2 (550)	"
7	5.5 (790)	"
8	9.5 (1,500)	"
8a	8.6 (600)	"

(Figures in parentheses represent the total number of stocks on each soil type).

If the stocks on types 1 and 1a in Yard 1, Centre 1, had not been grubbed, the average percentage for these soil types would certainly have increased greatly, as the number of stocks involved is high. Similarly, the grubbing of half of Yard 1, Centre 2, removed a large area of type 4a which was severely attacked by nettlehead.

Thus it might justifiably be supposed that the figures for types 1, 1a and 4a should be greater than those for the commonly occurring types 2, 3 and 3a, and 4.

Types 6 and 7 are small in their extent, and type 5 is rare, so that their significance in the above tables is low.

Types 8 and 8a, while quite large in area, only occur in one yard which is generally diseased throughout.

Incidence of Nettlehead:

Two points connected with the incidence of nettlehead should be noted here. The disease, under the Herefordshire system of planting hops, spreads more along the rows than across.

Figures of percentage disease are themselves average values for each soil type and cannot express the occurrence of nettlehead in concentrated areas. The disease maps should be consulted in conjunction with Tables I and II, as both the phenomena mentioned often tend to minimise the correlation between nettlehead and soil type.

(2) NUTRITIONAL DATA.

At present tissue test values provide the only available nutritional results as full chemical analysis of the laminae is not yet completed.

Selecting samples from areas typical of a particular soil type necessarily imposed restrictions on choosing diseased leaves where nettlehead was scattered. A further drawback to obtaining large amounts of nettlehead leaves was grubbing, especially in small but concentrated areas of the disease. Emphasis was placed on the soil, and it is possible to give comparisons between nutritional status on different soil types, and between healthy and diseased hops on the main soil types.

No difficulties were experienced with the tests, and a striking feature is the uniformity of the results. Nitrate nitrogen throughout was so low, often imperceptible, that the values have been omitted from the table presented.

The categories of marking are :

Trace	=	Trace	} These are qualified by + or — signs where necessary.
Low	=	L	
Medium	=	M	
High	=	H	

The calcium values mostly fall into the medium to low categories. This suggests that the hop plant has a calcium content normally low, rather than that calcium deficiency was a problem.

Table III sets out the values under the headings of mineral nutrients, and represents a collection of tests from all the yards.

TABLE III.

TISSUE TEST VALUES FOR HEALTHY AND NETTLEHEAD HOPS, IN RELATION TO SOIL TYPE.

PHOSPHATE.

Series	1st Sampling		2nd Sampling		3rd Sampling	
	Healthy	Nettlehead	Healthy	Nettlehead	Healthy	Nettlehead
1	LL+M—	LM—H—	L—L—L—L+	LL+	LL+L+	M
1a	M+		L—L+		M	
2	L+MM+M+	L+	LL+		LM—	
3 & 3a	H—H—		L		L+	
4	L+L+L+M—	M—	L—L—LLLL	L+	LLL+L+M—	M—M+
	M—M+M+H—		LL+		MMM+	
4a	LM—M+H—	L+H—H	L—M—	L+M+	LM—M—M	MM+M+
7	M—		M—		M—	
8	L+	L				
8a	L					

POTASSIUM.

Soil Series	1st Sampling		2nd Sampling		3rd Sampling	
	Healthy	Nettlehead	Healthy	Nettlehead	Healthy	Nettlehead
1	MMM+	M—MH—	MMM+M+	MM	M—MM+	M+
1a	M		M—M		M+	
2	MMM+H	M	MM		L—M+	
3 & 3a	MM	M	M+		L+	
4	MMMM	MH—H—	MMMM	M+	MMM+H—	H—H—
	M+M+M+M+		MMMM+		H—H—H—	
4a	MMM+M+	MM+H—	M+M+	MH—	M+M+H—	MH—H—
7	M+		M+		M+	
8	M+	M+				
8a	M+					

CALCIUM.

Soil Series	1st Sampling		2nd Sampling		3rd Sampling	
	Healthy	Nettlehead	Healthy	Nettlehead	Healthy	Nettlehead
1	L—LLL+	LL	LMM	M—M	L+M—M	M
1a	L		L—M		L—	
2	LLL+L+	L+	LL		Trace M+	
3 & 3a	LL		LL		L+	
4	Trace L—L—L	LL	L,LLL+	M	L—LM—M—	MM
	LLL, L+		M—M—M—M		M—M—M+	
4a	LLL+ Trace	L—LL	MM	L+M—	L+M—M—M	L, M—M
7	Trace		L+		M	
8	L—	L—				
8a	L—					

MAGNESIUM.

Soil Series	1st Sampling		2nd Sampling		3rd Sampling	
	Healthy	Nettlehead	Healthy	Nettlehead	Healthy	Nettlehead
1	MMM+	M—M—M	M—MMH—	MH—	H—H—H—	M+
1a	M+		M—M+		H—	
2	L+M—MM+	M	MH—		M+H—	
3 & 3a	M—M+		M+		H—	
4	MMMM	M—M—	M—M+M+	M+	M+M+H—H—	M+H—
	M+M+H—		H—H—H		H—H—H—	
7	H—		M+		H—	
8	M+	M+				
8a	M+					

Discussion of Table 3.

It will be seen that in no case is there a correlation between soil type and nutritional status, nor between nettlehead and nutrition as expressed by tissue tests. Seasonal trends are shown quite clearly, but are normal even

in diseased hops. A few samples were taken from replanted stocks, and these gave lower phosphate and magnesium values than the older stocks.

Phosphate values fluctuate slightly from one yard to another, as shown by the original tables which are not included in this report. Potassium is remarkably uniform, as is magnesium, with the exceptions noted above. Calcium shows the seasonal increase but is otherwise uniform.

This uniformity between samples is surprising, when the differences in size, constitution and particularly succulence of healthy and nettlehead leaves are considered. An explanation may lie in a differing proportion of cortex to stele in the petioles affecting the availability of nutrients for the tissue test technique.

DISCUSSION.

At present, chemical evidence, from both the soil and hop plant aspect, is so scanty that any suggestions put forward can only be very tentative. Also, the work reported was itself of a preliminary nature, to gain acquaintance with the nature of the problem.

This may have led to yards being chosen which were not altogether suitable, in that the disease had obtained a hold all over the yard irrespective of soil conditions, or other factors. This point is raised because nettlehead is often reported to be either confined to certain areas, or to have spread out from those areas, rather than to have appeared in a yard at many scattered points. The value of the diasease maps in plotting the spread is here obvious.

Each hop yard has many individual peculiarities, which cannot be brought into a report, or shown on a map, and notes for the yards have been prepared tracing the history of the field, disease and cultural details as far as possible. This task might well prove of great value on its own account.

The soil relation tables given above are of little value unless the maps are consulted at the same time, and future soil analyses must be chosen with regard to the maps of nettlehead incidence.

Detailed soil profile surveys would seem to be essential, as it has been found in some cases that an approximate survey has given an entirely false impression. This restricts the number of centres that can adequately be dealt with, especially when accurate disease maps are also necessary.

It is considered that the methods adopted were adequate to show correlations between nettlehead and soil conditions, and the nutritional status of the hop plant, besides providing data which may prove of value to other methods of approach.

Acknowledgment.

This work was carried out with the aid of a grant from the Agricultural Research Council.

CONCLUSIONS.

A survey was made of ten Fuggles hop yards on the Old Red Sandstone near Hereford. The object was to explore the relation between nettlehead and soil conditions, and the nutritional status of the hop.

At this stage in the work the following conclusions may be drawn:—

1. Nettlehead has a tendency to occur in localised outbreaks, and spreads most rapidly along the rows.
2. There may be a correlation between such areas and soil types 1, 1a and 4a.

3. There would seem to be no correlation, as shown by tissue tests, between the incidence of nettlehead and the content of nitrate nitrogen, phosphate, potassium, calcium and magnesium in the hop.

4. There would seem to be no correlation between soil types and the nutritional status, as shown in a similar way.

A PRELIMINARY SURVEY OF THE INSECTS ASSOCIATED WITH HOPS IN THE WEST MIDLANDS IN 1946.

By J. F. SOUTHEY.

Introduction.

During April—August 1946, a general survey was made of the insects and other fauna occurring in hopyards in the West Midlands. Detailed observations were made in Herefordshire and some hop farms in Worcestershire were visited. The aim of the work was to gain information on insects that might be associated with virus diseases, notably nettlehead and mosaic. The survey was not, however, confined to those orders of insects likely to be concerned in virus transmission but included all invertebrate organisms found feeding on hop plants, and some attention was given to the fauna of hedges and weeds around hopyards. The observations were, for the most part, qualitative, but some numerical data intended to give comparative estimates of insect populations are contained in the full report of the work. *

The Fauna of Rootstock and Soil.

Few studies were made of soil fauna except those of hop root eelworm, the only soil organism found that was obviously associated with the hop plant. Lemon-shaped *Heterodera* † cysts were found in association with the roots of hops and were present in most hopyard soils. The eelworms did not seem to affect the health of the stocks and Duffield (1) was unable to obtain any evidence that they were associated with the occurrence of nettlehead.

Examination of numbers of soil samples from hopyards in Herefordshire showed populations of 15–60 viable cysts per 25 c.c. of sieved soil. The presence of larvae and developing females in the cortical tissue of young hop rootlets was demonstrated by staining the tissue with acid fuchsin in boiling lactophenol, as described by M. T. Franklin (2). It was noted that larvae further from the root apices were at a later stage of development than those near them. This suggested that invasion of the root tissue occurred near the apex and developing larvae became further from the apex as root growth took place.

The Fauna of the Bines.

The hop flea beetle, *Psylliodes attenuata* Koch, was the first insect found on the young bines in spring. Early in April before the bines began to develop from the winter buds flea beetles were abundant and were feeding actively on

* This is lodged in the Library of the Long Ashton Research Station and can be consulted on application to the librarian.

† According to information recently supplied to Advisory Entomologists by M. T. Franklin and F. G. W. Jones, the Hop Root Eelworm has now been separated from other species and forms of *Heterodera* as *H. humuli* Filipjev.

nettles in the hedgerows. They assembled on the hops as soon as young leaves began to open (c. 10th April) and rapidly spread throughout the yards. The characteristic perforation of the leaves caused by these insects soon became conspicuous but damage was not sufficient to necessitate the use of control measures. Flea beetle numbers reached a maximum at the beginning of May and declined after the middle of May until by the end of June very few were present. Observations on hop insects were discontinued at the end of August and no records were obtained of further flea beetle attack on hops which, according to Massee (3), usually takes place in September.

Small numbers of the aphid *Macrosiphum gei* Koch occurred on the young vines in April at a farm under observation. It is not known whether this species is widely distributed, but it has been recorded on hops about this time in previous years and is well known as a vector of plant virus diseases.

The hop-damson aphid, *Phorodon humuli* Schr., was found on sloes, bullaces and plums in and near hopyard hedgerows at the beginning of May, and migration to hops began during the second week in May. Infestation of the vines, particularly the apices and young leaves, rapidly increased in intensity until the routine dusting with nicotine insecticide began in June. This treatment was the main factor that checked the development of aphid populations. During August the aphides persisted in small, roughly constant numbers in spite of the use of control measures. The work ceased before the second generation of winged forms was produced and so the return to winter hosts was not observed.

Predators and parasites found on the hop plants at this time undoubtedly played an appreciable part in the control of aphides. The chief among these was the ladybird, *Coccinella bipunctata* L., whose eggs and larvae were conspicuous about the leaves. Other enemies of *Phorodon* included, *Coccinella 7-punctata* L., *C. 14-punctata* L., *Halysia 14-guttata* L., *Anthocoris nemoralis* Fab., *Malthodes minimus* L. and other Cantharids, larvae of a Syrphid, various Braconidae and ectoparasitic red mites. During June when the aphid infestation was at its height the numbers of predators and parasites gradually increased. They remained high for a while after the attack had been checked by nicotine but decreased towards the end of July.

Thrips were fairly common and widespread on the hop plants from the middle of May until the end of August. Specimens were identified by Mr. F. Laing of the British Museum and they were, with one exception, *Thrips fuscipennis* Halid. The thrips occurred among the young leaves and stipules near the tips of shoots, on the undersides of leaves and, later, in the hop cones. In no case were they sufficiently numerous to cause noticeable injury, but their wide distribution made them of some interest as possible hop-virus vectors.

Early in May first instar nymphs of capsid bugs and leaf-hoppers made their appearance. The green capsid bug, *Lygus pabulinus* L., was common on hops before it reached maturity. It seemed unlikely that first instar nymphs could have walked to the hops from the hedge, a distance of at least a yard on bare soil, and so it was presumed that the eggs overwintered in the crowns of the stocks and hatched in April. The nymphs disappeared from hops early in June, just before their final moult, and shortly afterwards adults were common on nettles and other weeds in the hedgerows. The observations agree with the account given by Massee of the habits of *Lygus pabulinus* on black currants (3), and the appearance of adults on hops towards the end of August corresponds with their return to black currants at that season for egg-laying. No eggs were found on hop stocks or on plants in the hedge,

and further investigations of the life cycle of capsids on hops would be of interest.

Other insects occurred on hops occasionally, many of them only in isolated instances. Species of *Typhlocyba* and *Chlorita* were taken from May onwards. A few specimens of the large red and black leaf hopper, *Triecphora vulnerata* Illig., were found feeding on hop leaves near the hedges about the middle of May. This species was common on nettles, Umbelliferae, *Galium aparine*, etc., in the hedgerows at this time. A large metallic-green flea beetle, *Chalcoides aurata* Marsh., was found feeding on hop leaves in numbers in one hopyard about the middle of May. This species is generally found on willows and obviously came from willow trees growing near the stocks. The flies that frequented the hop plants throughout the season included numbers of Tipulids whose larvae may damage hop roots. Other insects present, in numbers too small to be of economic significance, included sawflies, ichneumons, tortrix and other caterpillars, capsids, membracids and Collembola (*Sminthurus* sp.). Many of these insects were found in greatest numbers during August after control measures had effectively reduced the hop damson aphid infestation.

The Fauna of the Flowers and Fruits.

No insects were found in the flowers or "burrs." The importance of insects in ripening fruits or cones was assessed by examining samples of 100 cones taken from different parts of the yards and collected in small bags. The commonest insect was *Thrips fuscipennis* Halid., whose status on hops has already been discussed. It did not cause noticeable injury to the cones. Other species found in the cones were *Phorodon humuli* Schr., nymphs of *Anthocoris* sp. (a predator on *Phorodon*), *Coccinella bipunctata* L. and a species of mite (Acarina).

The Fauna of the Hopyard Hedgerows.

Observations on the insects occurring on the weeds and hedges around hopyards were maintained during the season and a fairly representative collection was made. Though many of the insects found were never seen on hops, the observations contributed to an understanding of the behaviour of such insects as capsids. Special attention was paid to the fauna of the common nettle, *Urtica dioica*, and the elm because of their botanical relationship to the hop and their possible importance as alternative food plants. It is also possible that elm and nettle may act as symptomless hosts of hop virus diseases.

At the edges of the hopyards there was frequently a belt of rough grass and weeds with stinging nettles. Behind this there was usually a tall wind-break hedge, often of elm. Insects were collected from these with a fine mesh sweeping net. Mention has already been made of the part played by nettles and other weeds in the life histories of *Psylliodes attenuata* and *Lygus pabulinus*. Both of these insects were also found feeding on elm. Sloes and other *Prunus* spp. were common in the hedges and their significance in connection with the hop damson aphid was obvious. It is possible that such insects as the leaf hopper, *Triecphora vulnerata*, and the various Typhlocybrids which were common in the hedgerows and occasionally met with on hops, might become pests under favourable conditions. The observations suggested that pest incidence might be reduced if care was taken by hop growers in the selection of shrubs for windbreak hedges and hawthorn was chosen instead of

sloe or elm. Application of weedkillers to check the growth of nettles and other weeds might also be beneficial.

Hop Insects and Virus Diseases.

Although several virus diseases and suspected virus diseases occur in hops the mode of transmission is unknown. The two most important virus diseases are nettlehead and mosaic, and the former is probably the chief source of loss to the West Midland hop grower. The commonest variety of hop grown in this district is Fuggle, which is resistant to mosaic, but the more delicate varieties of the Goldings group which are occasionally grown are highly susceptible.

Since the natural mode of transmission of most well-known plant virus diseases is by insect vectors, it seems likely that virus diseases of hops are also spread in this way. Suspicion falls first on those insects whose method of feeding is similar to that of other known vectors, and whose numbers, distribution and movements would account for the distribution and spread of the disease. K. M. Smith (4) lists the following orders of insects as being concerned with plant virus transmission :—

Orthoptera.
Thysanoptera.
Hemiptera.
Coleoptera.

Of the insects in these orders found on hops, the following seem to have a distribution that could account for the incidence and spread of nettlehead and mosaic, and they are suggested as possible vectors :—

Thrips fuscipennis Halid.
Phorodon humuli Schr.
Macrosiphum gei Koch.
Lygus pabulinus L.
Psylliodes attenuata Koch.

Of these Massee (5) has tested *T. fuscipennis*, *Phorodon humuli* and *Psylliodes attenuata* so far with negative results.

Conclusion.

The preliminary survey shows that there are several directions in which future work in the West Midlands could be pursued. The life histories of insects associated with hops could be investigated since little is known of any other than the major pests, and information on such points as hibernation quarters and egg-laying sites would be useful.

The mode of virus transmission forms an important aspect of entomological work which needs study. The relation between the hop damson aphid and its predators and parasites forms another interesting field of study and the work of Ripper (6) might be continued to determine the optimum concentrations of nicotine that would reduce numbers of the aphides sufficiently to enable the predators and parasites to control the remainder without themselves being appreciably affected by the insecticide.

Acknowledgments.

Thanks are due to Dr. H. W. Miles and Dr. E. H. Wilkinson for help and advice during the work, and to Dr. H. W. Miles for suggestions regarding the

presentation of the reports. Acknowledgment is also made to the West Midland hop growers for their interest and co-operation and particularly to Captain C. Edwards, of Preston Wynne, Hereford, whose farm formed the chief centre for the detailed survey. This work was carried out with the aid of a grant from the Agricultural Research Council.

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CIDER APPLE PRODUCTION IN HEREFORDSHIRE : RESULTS FROM BURGHILL TRIAL ORCHARD, 1931-46.

By C. SAVIDGE.*

Cider has for centuries been a typical English drink, and the introduction of modern scientific methods into the cider factories has increased its popularity at home and abroad. There has for some time, however, been a considerable decline in the acreage under cider and perry fruit and in a normal year the home-grown crop is below the requirements of the cider makers.

The average yield for cider trees in England and Wales 1929 to 1938 was 55.8 lb. per tree, and perry pears was 49 lb. per tree (1). At 48 trees per acre, this is barely 1 ton 4 cwt. per acre for cider apples and 1 ton 1 cwt. per acre for perry pears. It is generally agreed the condition of existing orchards as regards pests and diseases is most unsatisfactory, and results in crops greatly below the potential capacity of the trees. In view of that position and the absence hitherto of any accurate detailed information on the crop production of English cider varieties, the investigations made by the writer on crop yields and orchard behaviour, together with spraying effects, are given as a contribution to more precise knowledge on this subject.

Material.

For upwards of thirty-eight years the Herefordshire County Council have maintained a demonstration orchard of six acres in the grounds of the County and City Mental Hospital, Burghill, Hereford. The lay-out and description of the early management has been described (2, 3, 4).

This orchard was planted under the National Fruit and Cider Institute scheme in November and December 1908 with the object of comparing the relative merits of some of the recognised good varieties of Herefordshire with other good varieties hitherto unknown in the county. The orchard site has a moderate and fairly regular slope with a fairly open and northern aspect and an altitude of about 300 ft. The soil is Old Red Sandstone contaminated by Welsh glacial drift and is a good deep loam with the exception of a part along the top bank where it is somewhat stony and only of moderate depth. Details of the mechanical and chemical analysis of the surface soil and subsoil have been described (3).

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Trees of twenty-five varieties were obtained from the Research Station, Long Ashton, and the late Mr. A. J. Manning, then County Instructor in Horticulture, supervised the lay-out and planting. Each variety occupies a single row of eleven trees running from bottom to top of the slope, and equal conditions have thus been secured for them. Distance of planting is 30 ft. square and in area each variety occupies 0.23 acre.

For several years before planting the land had been liberally treated and at planting time was under seeds, sown in 1907, from which a hay crop was taken the following year. For five or six years the orchard remained a pasture of poor quality which had been occasionally put up for hay. In 1916, the orchard was ploughed for the cultivation of arable crops during the first World War. As a result, it received generous manurial treatment and the trees made better growth. It was later laid down to permanent pasture and this is now grazed by a dairy herd. The orchard has not received any extra manurial treatment beyond occasional light dressings of straight N.P.K. before 1939.

Spraying Investigations.

Detailed observations on the different varieties began in 1931. The main purposes were to study, first, the cropping propensities of each variety over a period of years, and secondly, the varietal characters and pathological features of each variety. Later, it seemed desirable to investigate the major problems relating to the control of pests and diseases, and particularly the economic aspects of suitable spraying treatments. No data existed showing the increased yields of cider orchards resulting from a satisfactory pest and disease control (5).

With these considerations in mind it was clear that it would be wise to ascertain first the effect of tar oils only. If winter spraying proved beneficial and economical, additional applications of a suitable fungicide in spring might also prove satisfactory. These extra sprayings, however, might be too costly and not repay the expenditure especially in a light crop year. In subsequent years, therefore, one, or perhaps two, sprayings could be omitted.

Winter spraying was first carried out in 1933 and again in 1934 and no extra sprays were applied. During the next six years, 1935 to 1940, one winter and two spring sprayings were regularly given, but later during the war it was not possible to give the orchard the same attention as regards spraying. Winter sprayings only were carried out in 1941 and 1942, followed by a winter spraying and one spring spraying in 1943. No spraying treatment was given in 1944 and 1945 and the orchard received a single combined insecticidal and fungicidal spraying in the spring of 1946.

In view of the influence of the spraying treatments in crop yield and tree response, it is desirable to consider these in detail before the data on individual varietal behaviour are given.

Methods of Application and Spraying Costs.

Spraying costs vary within wide limits according to management, distance from the water supply, and the kind of labour and equipment used. In the Trial Orchard at Burghill water was laid on and the supply was fairly adequate. Four different spraying machines were used and until 1940, the actual tree spraying was done by certain inmates of the Mental Hospital. These men worked under the direct supervision and instructions of a spraying supervisor who also attended to the running of the machine, mixed the spray fluids, and kept records from which costings were ascertained.

In 1933 the spraying was done with a manual pump moved from tree to tree. From 1934 to 1939 with a 5 H.P. semi-portable machine which maintained a pressure at the pump of 250–300 lb. per sq. in., and was provided with overland mains and 300 ft. lengths of spraying hose. With this outfit 9 ft. lances fitted with single adjustable nozzles were at first used, but a change was quickly made in 1934 to spray guns, and then to 2-jet nozzles of Noblox and Broadway design. This outfit was given to the Herefordshire County Council Agricultural Education Sub-Committee by Messrs. H. P. Bulmer & Co., Ltd., Cider Makers, Hereford, for spraying orchards in the county on contract at bare costs. Data are described in detail of the working costs and time taken per acre to spray the Burghill orchard with this machine 1934–1936 (6) and 208 acres of Herefordshire cider orcharding in 1934 (7).

In 1940, Messrs. Bulmer replaced this outfit with a more powerful machine of mobile type capable of giving a pressure of 600 lb. per sq. in., using two 60 ft. lengths of spray hose with 6 ft. lances fitted with double Broadway nozzles. This machine was used in this orchard until 1942, after which the spraying was done on contract by the C.W.A.E.C. with a Friend mobile sprayer and W.L.A. labour.

Winter washes were used at 6 and $7\frac{1}{2}$ per cent. concentration standard tar-distillate, and 8 per cent. D.N.C. mostly in March. The tar-distillate was applied at $7\frac{1}{2}$ per cent. in 1933, 1936, 1937, 1938, 1940 and 1941; and at 6 per cent. in 1934, 1935, 1939 and 1942; and D.N.C. 8 per cent. in 1943.

The special difficulties arising in an orchard of mixed varieties made it difficult to apply the lime sulphur scab spray when all varieties were in the "green cluster" stage. Pre-blossom spraying therefore was carried out when the majority of the trees were in the "green cluster" stage. Lime sulphur was applied at "green cluster" stage at 1 in 30 during the seven years 1935–1940 and 1943; in 1946 at 1 in 100 with nicotine, arsenate of lead and a wetter added. In 1935, 1938 and 1946 the "green cluster" stage was reached in April and during the other years in May. Post-blossom sprayings were given at "petal fall" either in May or June, using lime sulphur 1 in 60 in 1935 to 1937, and 1 in 100 from 1938 to 1940.

In Table I are summarised the average costs of spraying and quantities of dilute wash used by each of the four spraying machines. The costings are separated into two periods:—1. pre-war, 2. war and post-war in order to bring out the differences in spraying costs. The costings for 1934–1943 include charges for fuel and oil, repairs and replacements, and spray fluid and labour but exclude charges for depreciation of plant and interest on capital. These charges are all included, however, in the 1943 and 1946 costs.

As shown in the table there was some considerable variations in the costs of spraying by hand and by power machine pre-war; and between winter spraying by power pre-war and later. The differences in the amount of wash used is not marked except in the pre-blossom spraying done by the C.W.A.E.C. outfit where different labour was employed and overheads are also much greater. There was no marked difference in the amount of wash applied after $1\frac{1}{8}$ acre of the trees were top-grafted in 1937 and 1938, except in the case of the pre-blossom sprayings in 1939 and 1940. The pre-war costs for winter spraying with tar-oil are in good agreement with those described by Swarbrick (5) in 1932, and by the writer in 1935 (7) and 1938 (6). Swarbrick showed that working with similar trees and using tar-oil at $7\frac{1}{2}$ per cent. the cost of spraying in 1928 worked out at about 1s. 3d. per tree, and 1s. 0d. per tree in 1929.

TABLE I.
SPRAYING COSTS.

Treatment	Per Acre average	Per Tree average	Dilute wash per acre average
	£ s. d.	s. d.	galls.
Pre-war ; manual pump.			
1933 Tar-oil	4 3 4	1 8½	233
Pre-war ; H.C.C. power pump, mains.			
1934-1939 Tar-oil	1 10 5	7½	233
1935-1939 Lime sulphur, pre-blossom ..	16 10	4½	189
1935-1939 Lime sulphur, post-blossom ..	13 6	3	290
War and Post-war.			
H.C.C. power pump, mobile			
1940-1942 Tar-oil	2 14 7	1 1½	233
1940 Lime sulphur, pre-blossom	14 11	3½	160
1940 Lime sulphur, post-blossom	11 0	2½	250
C.W.A.E.C. power pump, mobile.			
1943 D.N.C.	3 5 0	1 4½	183
1943 Lime sulphur pre-blossom	3 0 0	1 3	316
1946 Omnibus	5 8 6	2 3	333

Effects of Spraying on Yield.

As regards the actual annual increase of the cider apple crop due to spraying at Burghill strictly comparative data are not available, no trees being left unsprayed as controls. The whole orchard was sprayed from 1933 to 1946 with the exception of 1944 and 1945, and crop data are available also for 1931 and 1932, the two years prior to the start of spraying treatment.

The yield of fruit from this six-acre orchard is summarised in Table II. This summary deals with all trees in the orchard, including rogue varieties, re-grafted trees, and a few trees in a corner of the orchard.

TABLE II.
ORCHARD YIELD.

	tons.	cwts.		tons.	cwts.
1931 unsprayed	4	11½	1939 tar-oil: L.S. twice ..	60	1½
1932 unsprayed, pruned ..	2	2	1940 tar-oil: L.S. twice ..	9	1½
1933 tar-oil	28	2	1941 tar-oil	25	0
1934 tar-oil	4	12	1942 tar-oil	7	8
1935 tar-oil: L.S. twice ..	16	3½	1943 D.N.C. L.S. once ..	23	14
1936 tar-oil: L.S. twice ..	30	12	1944 unsprayed	30	6
1937 tar-oil: L.S. twice, pruned ..	28	5½	1945 unsprayed	9	16
1938 tar-oil: L.S. twice	11	2	1946 omnibus once	29	11

The total yield from the orchard for the last sixteen years has been 320 tons 8 cwts., and returns for fruit £2,763. Calculated on an area basis this gives an average yield of 3 tons 8 cwts. and a return of £28 15s. per acre for the sixteen year period.

The average yield during the four-year period when the orchard was not sprayed was 1 ton 19 cwts. per acre. During this period unfavourable weather and spring frosts in 1932 and 1945 contributed to some extent, but there is no doubt the omission of spraying adversely affected the yield especially in 1931 and 1932. There was also a slight spring frost in 1944, but the yield was heavy and the trees doubtless benefited from previous sprayings.

During the four-year period when tar-oil was applied the average yield rose to 2 tons 14 cwts. per annum, which included a spring frost in 1941.

The orchard contributed the heaviest average annual yield when it was sprayed with one tar-oil and two lime sulphur sprays annually, *i.e.* 4 tons 3 cwts. per acre for the six-year period. This period included the two serious spring frosts of 1935 and 1938.

The yields after spraying with D.N.C. and one lime sulphur application in 1943, and the omnibus wash in 1946, were 3 tons 19 cwts., and 4 tons 18 cwts. respectively. As these were applied once only each it is unsafe to generalise on their effects.

No appreciable spray damage resulted from the pre-blossom spraying with lime sulphur, although in 1936, Cherry Norman, Court Royal, and Yarlinton Mill were slightly damaged, but no signs of damage were later observed on the foliage of any variety in mid-June. In 1937, following pre-blossom spraying with lime sulphur 1 in 30 on May 4th and 5th, and 1 in 60 post-blossom on June 5th some notes on sulphur-sensitiveness were recorded on 19th June:—

No leaf scorch:—Dymock Red, No. 32 Ashton, Knotted Kernel, Cap of Liberty, Eggleton Styre, Sweet Alford, Cowarne Red.

Very slight leaf scorch:—Kingston Black.

Slight leaf scorch:—Kingston Black Improved, Yarlinton Mill, Court Royal, Crimson King, Skyrmes Kernel, Improved Pound.

Noticeable leaf drop:—Hereford Redstreak, Cherry Norman, Fair Maid of Devon, Strawberry Norman.

Considerable leaf drop:—Dabinett, Sweet Coppin, Old Foxwhelp.

Varietal Behaviour.

Total Average Annual Crop Yields.

The data in Table III indicate the wide variations in yield, returns and orchard value of the varieties between the tree age of 27 to 42 years inclusive. The table deals with only 21 of the 25 varieties originally planted. The remainder, *viz.*, Killerton Sweet, Somerset Redstreak, Butleigh No. 14 and Medaille d'Or are not included owing to rogue varieties in the rows and consequent difficulty in separating the fruit at harvesting time. The yield of the good vintage variety Old Foxwhelp is undoubtedly adversely influenced by an adjoining hedge. Yields from the variety planted as Somerset Redstreak have been heavy. The returns per acre are based on two period prices, *viz.* (a) Kingston Black and Foxwhelp £6, other varieties £4 per ton pre-war, and (b) all at the present price of £14 per ton. The data for Hereford Redstreak, Cowarne Red, Skyrmes Kernel and Dymock Red cover 6 years only, and other varieties for 16 years. As there are eleven trees (0.23 acre) of each of the twenty-one varieties, except six varieties with one to two trees less, there is some justification for expressing the tree yields as yields per acre: but this must be regarded as comparative only.

Variation in Annual Yield.

In Fig. 1 the seasonal yield of the first sixteen varieties in Table III are shown. The varieties Hereford Redstreak, Cowarne Red, Skyrmes Kernel, and Dymock Red, having earlier proved their unproductiveness and were top-grafted, are not included; Old Foxwhelp is also omitted for reasons previously given.

TABLE III.
AVERAGE ANNUAL CROP AND RETURNS.

Variety	Type	Average Annual Crop				Average Annual Returns	
		per tree		per acre		per acre	
		cwts.	lbs.	tons	cwts.	£	£
Yarlington Mill	B. swt.	3	75	8	16	35	123
Fair Maid of Devon	Shp.	2	110	7	3	28	100
No. 32 Ashton	B. swt.	2	91	6	15	27	94
Dabinett	B. swt.	2	81	6	10	26	91
Sweet Coppin	Swt.	2	74	6	8	25	89
Improved Pound	Swt.	2	0	4	16	19	67
Kingston Black Improved	Shp.	1	100	4	11	27	64
Sweet Alford	Swt.	1	92	4	7	17	61
Crimson King	Shp.	1	91	4	7	17	61
Court Royal	Swt.	1	81	4	2	16	57
Kingston Black	Shp.	1	63	3	15	22	52
Knotted Kernel	B. swt.	1	48	3	8	14	47
Strawberry Norman	B. swt.	1	19	2	16	11	39
Cap of Liberty	Shp.		94	2	0	8	28
Cherry Norman	B. swt.		87	1	17	7	25
Eggleton Styre	Swt.		51	1	2	4	15
Old Foxwhelp	Shp.		14		6	2	4
Hereford Redstreak	Shp.		45		19	4	13
Cowarne Red	Shp.		41		17	3	12
Skyrmes Kernel	Shp.		39		16	3	11
Dymock Red	Shp.		11		4	1	3
						at £4 Ton *	at £14 Ton

* Kingstons and Foxwhelp at £6 ton

It is evident from Fig. 1 and Table III, that twelve varieties have proved to be of orchard value under good orchard management where the remainder have failed to crop satisfactorily. The chief reason for the variability is the resistance or susceptibility of the varieties to apple canker fungus. The yield from susceptible varieties was not markedly improved by the spray treatment although there was a very slight improvement in the cropping of Strawberry Norman and Cap of Liberty from the lime sulphur sprayings. It is also clear that this fungicide improved the yield of Kingston Black and Kingston Black Improved. It can also be seen that there was a tendency of some varieties to biennial cropping.

General Orchard Characters.

The characteristics of each variety in the foregoing data have been studied since 1931. In 1933, measurements of trunk girth $4\frac{1}{2}$ ft. from ground level were taken and the average girth of each variety is given. The branches of certain varieties now touch each other and they require a greater distance than 30 ft. between the trees, viz., Cherry Norman, Court Royal, Crimson King, Improved Pound, Kingston Black, Kingston Black Improved, Knotted Kernel, Strawberry Norman, and Sweet Coppin.

Cherry Norman. Bittersweet: girth 23.7 in. Very large upright tall spreading full head, much ingrowing wood. Susceptible to canker, *Cytospora*, scab, red spider, woolly aphid. Foliage, variable often defoliates early from apple scab. Fruit, early, small, much scab. Crop: poor.

Cap of Liberty. Sharp: girth 15.9 in. Small to fairly large open spreading head, short spurs, sparse lateral growth. Susceptible to canker when middle-aged. Foliage good in spring, often falls later following scab. Fruit, mid-season, medium to large, much scab, prone to sawfly and water-core. Crop, poor.

Court Royal. Sweet: girth 23.5 in. Fairly large to large horizontal spreading head, thickly provided with short spurs, pendulous when loaded with fruit and liable to damage by stock. Susceptible to *Cytospora* and slight seasonal attacks of woolly aphid. Foliage, generally

FIG. 1a—AVERAGE YIELDS PER TREE 1931-1946.

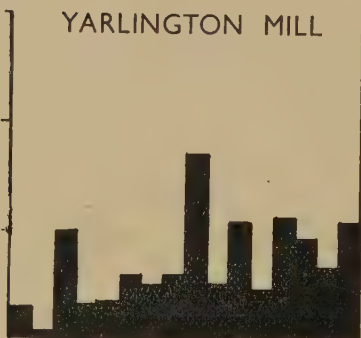
cwt

15

YARLINGTON MILL

10

5



FAIR MAID OF DEVON



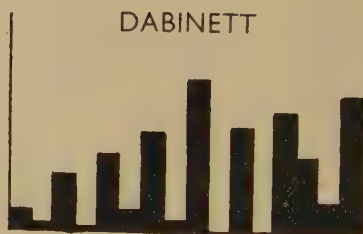
10

No. 32 ASHTON

5



DABINETT



10

SWEET COPPIN

5



IMPROVED POUND



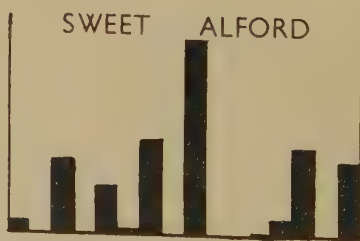
10

KINGSTON BLACK
IMPROVED

5



SWEET ALFORD



1931

2

3

4

5

6

7

8

9

1940

1

2

3

4

5

6

1931

2

3

4

5

6

7

8

9

1940

1

2

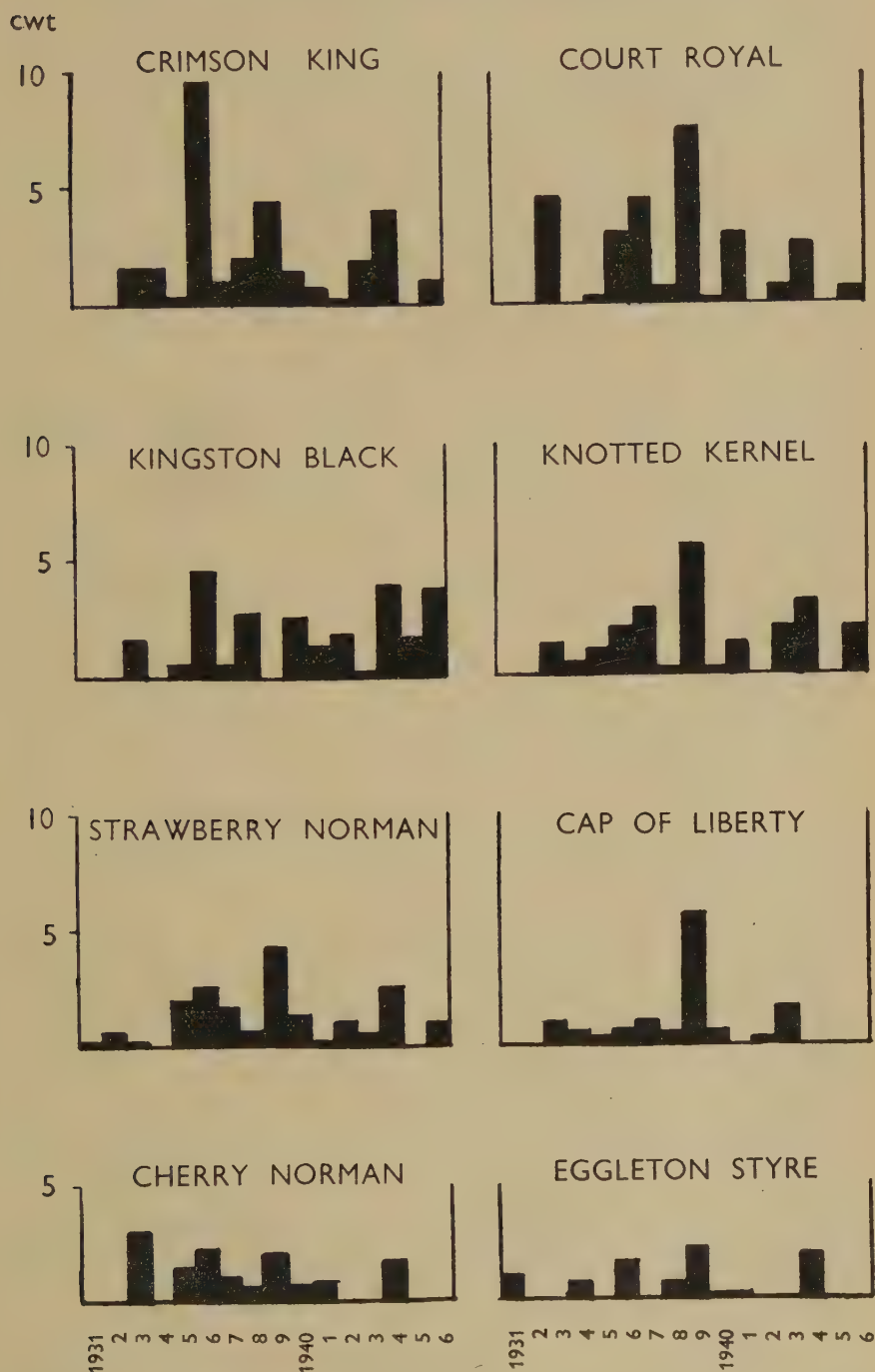
3

4

5

6

FIG. 1b—AVERAGE YIELDS PER TREE 1931-1946.



very healthy but subject to caterpillar damage. Fruit, mid-season, moderately large, slightly prone to scab and brown rot. Crop, good.

Cowarne Red. Sharp: girth 15.9 in. Small to fairly large upright compact spreading head, short spurs, sparse lateral growth. Very susceptible to canker and die-back. Foliage, poor, subject to caterpillar and scab. Fruit, mid-season, small, much scab. Crop, poor.

Crimson King. Sharp: girth 24.9 in. Very large upright spreading very full head. Foliage good. Fruit, late mid-season, medium large, clean. Crop, good.

Dabinett. Bittersweet: girth 17.4 in. Small to fairly large upright spreading head, thickly provided short spurs. Foliage good, but some seasonal red spider. Fruit, late, medium, clean. Crop, heavy.

Dymock Red. Sharp: girth 22.8 in. Large spreading head, somewhat unshapely, inclined to upright growth, much lateral growth which spurs readily, long spurs. Very susceptible to canker and scab. Slightly prone to *Cytospora* and woolly aphid. Foliage, scab, mildew, scorch. Fruit, late mid-season, medium, scab marked. Crop, bad.

Eggleton Styre. Sweet: girth 19.2 in. Fairly large to large tall upright spreading compact head, thickly provided with short spurs, many suckers and ingrowing laterals which readily spur. Susceptible to canker, *Cytospora*, scab. Foliage poor, subject to scab and scorch. Fruit, mid-season, medium, scab marked. Crop, poor.

Fair Maid of Devon. Sharp: girth 22.8 in. Fairly large to large spreading full head, very thickly spurred, short spurs, thick lateral growth. Often badly infested with woolly aphid. Foliage, thick, good. Fruit, late mid-season, medium, very susceptible to brown rot and slightly prone to sawfly. Crop, heavy.

Hereford Redstreak. Sharp: girth 19.4 in. Fairly large upright spreading head, well spurred. Very susceptible to canker, scab, and slightly prone to woolly aphid. Foliage, poor, subject to scab and red spider. Fruit, mid-season, medium to large, much scab. Crop, poor.

Improved Pound. Sweet: girth 25.7 in. Fairly large to large horizontal spreading head, short spurs. Pendulous when loaded with fruit, droops and liable to damage by stock. Foliage, slightly prone to mildew. Fruit, mid-season, large. Crop, good.

Kingston Black. Sharp: girth 19.7 in. Fairly large to large upright spreading head, thickly spurred. Foliage, very susceptible to scab, mildew, red spider, and scorch; prone to early defoliation by scab. Fruit, mid-season, small to medium, scab marked. Crop, good.

Kingston Black Improved. Sharp: girth 19.2 in. Large to very large, upright spreading full head. Foliage, dark colour very healthy but slightly prone to seasonal red spider. Fruit early mid-season, medium, susceptible to sawfly in some seasons, more resistant to scab than Kingston Black. Crop, good.

Knotted Kernel. Bittersweet: girth 24.7 in. Very large upright compact tall full head, thick lateral growths, occasionally prone to woolly aphid. Foliage, generally good but subject to seasonal red spider; slight defoliation 1936 from leaf-miner. Apparently comes into full bearing much later than other varieties. Fruit, early mid-season, small, clean. Crop, good.

No. 32 Ashton, Syn. Ashton Brown Jersey. Bittersweet: girth 20.1 in. Fairly large to large upright spreading head thickly provided with short spurs. Foliage, good. Fruit, late, medium. Crop, heavy.

Old Foxwhelp. Sharp: girth 13.1 in. Very small upright spreading head, well spurred. Foliage, slightly prone to mildew. Blossom occasionally badly infested with blossom weevil. Fruit, mid-season, medium to large, but this does not seem to be the true Old Foxwhelp. Crop, adversely affected by nearby hedge.

Skyrnes Kernel. Sharp: girth 18.4 in. Small upright spreading compact head, short spurs, sparse lateral growth. Susceptible to canker, *Cytospora*, scab. Foliage, poor, subject to scab, mildew, scorch. Fruit, mid-season, small, scabbed marked. Crop, poor.

Strawberry Norman. Bittersweet: girth 22.6 in. Large to very large horizontal spreading head tending to droop when fruiting; thickly provided with short to medium spurs, strong ingrowing laterals which spur readily. Very susceptible to canker, and scab; slightly prone to *Cytospora* and woolly aphid. Foliage, subject to red spider and scab. Fruit, late mid-season, medium, scab marked. Crop, poor.

Sweet Alford. Sweet: girth 22.1 in. Large to very large upright spreading full head thickly spurred. Subject to *Cytospora* and scab. Foliage, variable, slight mildew, scab, red spider. Fruit, late mid-season, medium, occasionally scab marked. Crop, good.

Sweet Coppin. Sweet: girth 22.2 in. Large to very large upright spreading head, thickly spurred. Prone to seasonal woolly aphid. Foliage, good with seasonal red spider. Fruit, mid-season, generally large but coming small in some seasons. Scab marked in wet season after middle age. Crop, heavy.

Yarlington Mill. Bittersweet: girth 19.5 in. Fairly large spreading full head thickly spurred, thick lateral growth. Often pendulous with heavy load of fruit and branches subject to breakage unless supported. Foliage, very good and apparently resistant to damage by pests and diseases. Fruit, late, medium to large with some bloom. Crop, very heavy.

Frost Resistance of Blossom.

Observations were made on varietal resistance to frosts at blossoming time in 1938 at Burghill and two other Trial Orchards in Herefordshire (8). It was found that cider apples in the main were less damaged than were market

varieties. The blossom buds of some cider varieties, however, were frozen in the "bud burst" and "green cluster" stages and data on frost damage are given. At Burghill there was very little blossom on the varieties Kingston Black Improved, Fair Maid of Devon, Sweet Coppin and Sweet Alford. A peculiar feature of the spring frost in 1938 was the susceptibility of Sweet Coppin and Dabinett, whereas both varieties were practically resistant to the frost in 1935. None of the eight varieties in the "very bad" group are of the bittersweet type. Four bittersweet varieties Bedan, Royal Jersey, Fertile de Caen, Medaille d'Or were placed in the "bad" group of nine varieties but each subsequently yielded heavy crops.

The resistance of nine varieties is slightly variable, viz. Killerton Sweet, Strawberry Norman, Neverblight, Cherry Norman, Lambrook Pippin, Sweet Woodbine, Eggleton Styre, Fair Maid of Devon, Cap of Liberty.

TABLE IV.
FROST DAMAGE, 1938.

Trial Orchard	Nil to Practically Nil	Very Slight	Slight	Slight to Bad	Bad	Very Bad
Burghill ..	Kingston Black Yarlington Mill Killerton Sweet	Strawberry N. Old Foxwhelp 32 Ashton Eggleton S.	Cherry N.	Dabinett Knotted K.	Fair Maid of Devon	S. Coppin Fair Maid D. Court Royal Crimson K. Improved P. Cap of Liberty
Pixley ..	Frequin A. Neverblight Yarlington M. Strawberry N. White N. Lambrook P. Cherry N. S. Woodbine	S. Woodbine	Lambrook P. Bulmers N. Neverblight		S. Woodbine Bedan Dymock R.	S. Coppin Langworthy Eggleton S.
Kinnersley ..	Strawberry N. Yarlington M. Neverblight R. Wilding Cherry N. Old Cadbury Chisel J. Hy Masters J. S. Alford				Woodbine S. Woodbine Royal J. Cap of L. Fertile de Caen M. d'Or Bramleys S. Newton W.	

Discussion.

The primary object of the investigations was to determine the orchard merits of a number of recognised good varieties of cider apples and it is clear there are wide differences between some of them. Some of the best known varieties grown at the Trial Orchard, Burghill, have proved of no orchard value. Data available from other sources in Herefordshire are closely comparable.

Methods which have been widely used for the control of pests and diseases of other apples have been neglected for cider varieties, due no doubt to economic considerations in the absence of available data. Cider apples, therefore, were not expected to yield economic financial returns from expenditure incurred by spraying. The evidence clearly shows, however, that routine spraying in winter and spring is a profitable undertaking, providing the trees sprayed are free from apple canker.

The yields obtained show definitely that crop yield is linked more to freedom from canker than to any other orchard factor. The first essential, therefore, for the production of good crops and high returns is the provision of

resistant varieties. Moreover, the reaction of canker susceptible varieties to apple scab is most marked. While eleven of the twenty-one varieties were scab susceptible, three only were apparently resistant to canker and they alone showed any marked benefit from fungicidal sprayings, viz., Sweet Alford, Court Royal, and Kingston Black. It is therefore concluded that the effect of canker in cider orchards in general is more serious than can be deduced from the present investigations conducted on a limited number of varieties.

Further, the observations on the incidence of red spider mite suggest that it is unwise to continue yearly applications of tar-oil without at the same time applying lime sulphur during the post-blossoming period, or D.N.C. occasionally as an alternative to standard tar-distillates. As there were spasmodic infestations of Woolly Aphis on certain varieties following upon regular applications of tar-oil, extra control precautions against this pest are desirable.

Finally, it is evident that a cider orchard of suitable varieties is a good investment. In fact, it is one of the most remunerative sections of farming.

Acknowledgments.

The writer thanks Mr. E. T. Abel and Mr. E. Ballinger of the staff of the Mental Hospital, Burghill, for their great help during the routine work over a long period of years.

Summary.

Observations on the relative merits and orchard behaviour of certain varieties of cider apples from 1931 to 1946 are recorded and described.

Qualitative and quantitative data as to the general growth characters, yields, and returns of the varieties, as well as their resistance to frost damage at blossoming time are tabulated and described.

Quantitative data regarding application and the result of certain spray treatments are tabulated and examined.

The results from spraying emphasized that a regular routine programme of three sprayings each year significantly increases the crop yield of varieties resistant to apple canker fungus and is an economical and profitable undertaking.

The incidence of canker adversely affects fruit yield and the spray treatments had no significant effect in increasing the yield from canker-susceptible varieties.

It is suggested that the planting of varieties resistant to this fungus is the essential requirement to profitable cider apple culture and the cider making industry. The crop yields show that the varieties most affected with apple canker are almost valueless.

The estimated average yield for cider trees in England and Wales is officially stated as 55.8 lb. per tree, while the heaviest cropping variety in the orchard described averaged 411 lb., and the lowest 11 lb. per tree. Evidence is therefore advanced to prove the case for planting approved varieties.

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THE DETERMINATION OF THE TITRATABLE ACIDITY OF APPLE JUICE AND CIDER.

By L. F. BURROUGHS.

In the course of certain preliminary investigations on the changes in composition of the juice during the maturing of the apple, it became necessary to develop a more precise routine determination of the titratable acidity. The method then in use was that described by Mehltitz (1) and Charley and Harrison (2).

The acidity of apple juice is almost entirely due to the presence of *l*-malic acid; in cider, lactic, acetic and other organic acids produced during the fermentation may be present in varying amounts. Malic acid, however, is the predominant acid in both apple juice and cider, and their acidity is commonly expressed as "percentage malic acid," *i.e.* grams of malic acid per 100 mls. of cider. For the purpose of this paper the acidity is considered to be entirely due to malic acid, and for practical purposes this is a justifiable assumption. It is also assumed that the problem of the determination of the titratable acidity of apple juice is essentially the same as that of cider, and in the rest of this article reference is made only to cider.

It is important to remember that the free malic acid of cider is strongly buffered by the presence of malates. In effect, the total malic acid content of the cider may be considered as being partially neutralised by the basic constituents (chiefly potash) of the mineral ash. The titratable acidity is due to, and is a measure of, the residual free malic acid plus acid malic salts, *e.g.* potassium hydrogen malate. The relation of titratable acidity, pH, and ash content of apple juice has been studied by Haynes and Brown (4), and is outside the scope of the present article.

Methods at present available.

The determination of titratable acidity consists essentially in the neutralisation of an aliquot portion of the cider with a standard solution of caustic soda. It is a matter of convenience to use 10 mls. of cider and *N*/6.7 caustic soda, so that the titration figure divided by 10 gives the acidity directly in terms of grams malic acid per 100 mls. of cider.

The various methods which may be employed to detect the neutrality point may be grouped into three classes.

1. Methods using an external indicator.
2. Methods using an internal indicator.
3. Electrometric methods.

The advantages and disadvantages of the first two general methods are briefly discussed in the following paragraphs.

Electrometric methods of following the pH change are undoubtedly

capable of the greater precision, but the apparatus required is expensive and is not always available. Furthermore, trouble may be experienced with the "poisoning" of the electrodes.

For routine purposes a method employing an internal indicator is the most convenient, and is satisfactory provided that the end-point is sharp and represents the true neutrality of the cider.

During the course of neutralisation the natural pigments of the cider undergo a colour change from yellow to dark reddish-brown; the extent of this change, and the final shade, both depend on the nature of the cider. The colour change obscures the end-point of any internal indicator used, unless the solution is largely diluted with water.

This difficulty can be overcome by the use of an external indicator. The method given by Mehlitz (1) and Charley and Harrison (2) is a direct titration of undiluted juice using blue litmus paper as an external indicator. This procedure, which was introduced by Lloyd (3), has been used in the past at Long Ashton, and is quite satisfactory for ordinary routine purposes with ciders of moderate acidity. It is insensitive, however, for ciders of low acidity (less than 0.2%) since the percentage error is greater and, as will be shown below, these ciders are very strongly buffered. Another external indicator which is commonly used is a solid mixture of phenolphthalein and potassium sulphate; the details are described in the A.O.A.C. Handbook of Methods (5), in the section dealing with the analysis of wines.

The use of external indicators is, however, inconvenient, and attended by certain fundamental sources of error. For these reasons, the alternative method given in the A.O.A.C. Handbook is preferable. It employs the dilution of the wine with a large excess of boiled-out distilled water, and the addition of phenolphthalein as an internal indicator.

The method described below is a modification of this procedure and is an improvement in two respects:—

1. The effect of the absorption of atmospheric CO_2 during titration, causing fading of the end point, is overcome by stirring the solution with a stream of CO_2 -free air.

2. The indicator used is a mixture of Brom-thymol Blue and Phenol Red which changes sharply from blue-green to purple between pH 7.4 and 8.0. Phenolphthalein changes from colourless to red between pH 8.3 and 10.0, with a pK value of 9.6.

In using the mixed indicator, the progress of the titration is made apparent by the change of colour from yellow (below pH 6) to green (pH 6 to 7.4) through grey to purple (pH 8.0). In this way visual warning of the approaching neutrality is given by the green colour, and the appearance of the grey colour is taken as the end-point. It is shown in the following section that the pH range of 7.4 to 8.0 corresponds more closely to the true neutrality of cider than does the colour change of phenolphthalein (pH 8.3 to 10.0, pK 9.6).

Experimental.

A series of typical ciders of the sharp, sweet and bittersweet classes were titrated with standard caustic soda and the progress of neutralisation was followed by electrometric determination of the pH. The cider, previously de-gassed *in vacuo* was contained in a small beaker and was stirred continuously with a stream of nitrogen to prevent absorption of atmospheric CO_2 . The pH was determined, following each addition of caustic soda, by a Cambridge pH-meter using a calomel/glass electrode system.

The ciders used were :—

A. Frederick.	Sharp class, with high acid and low tannin.
B. Sweet Alford.	Sweet „ „ low „ „ „ „
C. Medaille d'Or.	Bittersweet „ „ „ „ high „

The results are expressed graphically in Fig. 1, as pH/titration curves showing the relative rates of neutralisation. It is seen from the slopes of these curves that the degree of buffering shown by the three ciders increases in the order A, B, C. This difference is brought out more clearly in the pH/neutralisation curves (Fig. 2). These curves are based on the fact that the point of inflection in the pH/titration curve represents the true neutrality point of the cider; regarding this titration value as 100% neutralisation, the pH/neutralisation curve is then plotted on a percentage basis.

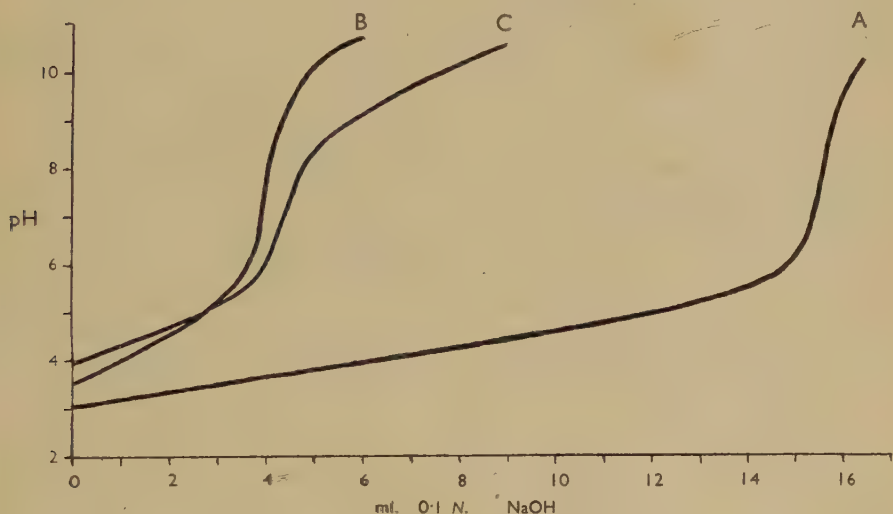
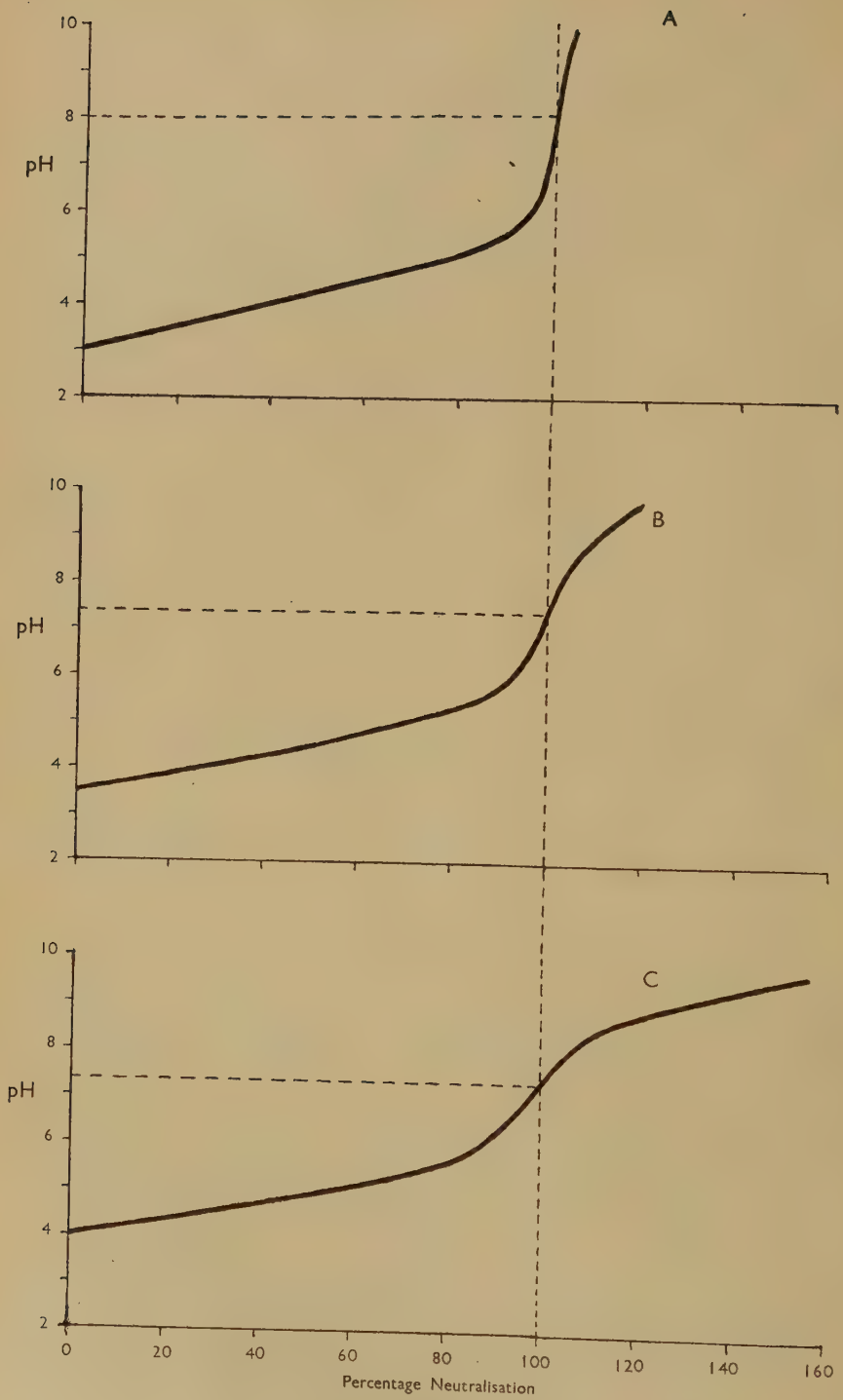


Fig. 1

The important point demonstrated by these curves is that the pH of neutralisation of cider lies in the range of 7.4 and 8.0, which is slightly below the colour change of phenolphthalein, but corresponds closely to the grey colour of the mixed indicator.

The acidities of the same three ciders (A, B and C) were then determined by the method described in the subsequent section of this paper, again following the course of the titration by electrometric determination of the pH. The results were plotted as before to obtain pH/titration curves, and from these the pH/neutralisation curves were derived. The second series of curves, *i.e.* those for 10 mls. of cider diluted with 100 mls. of indicator solution, were almost identical in the pH range of 6.0 to 9.0 with the first series obtained with undiluted cider. They differed from the first series mainly in that the pH of the diluted cider before titrating was about 0.1 to 0.2 pH unit higher than the pH of the corresponding undiluted cider. Therefore the addition of 100 mls. of indicator solution to 10 mls. of cider does not appreciably affect the course of titration and the neutrality point remains in the region of pH 7.4 to 8.0.

*Fig. 2*

METHOD.

Reagents.

Indicators 0.2% *Bromo-thymol blue*.

2 gms. of bromo-thymol blue is triturated in a clean glass mortar, with 35 mls. of 0.1 N NaOH and diluted to 1 litre with distilled water.

0.1% *Phenol red*.

This is made up as in the above instructions for bromo-thymol blue, using 1 gm. of phenol red and 30 mls. of 0.1 N NaOH.

To prepare the diluted indicator solution, 20 mls. of each of the stock solution are added to 4 litres of distilled water. The solution is then freed from CO_2 by warming to approximately 45°C . and running through a deaerating column in a vacuum sufficient to cause vigorous boiling of the solution as it passes down the column. The solution, which should be brownish-yellow ("sooty" yellow is a more accurate description) is stored in a $4\frac{1}{2}$ litre bottle protected with a soda-lime tube, and fitted with a syphon arrangement leading to an automatic measuring device set to deliver 100 mls.

 CO_2 -free air

This is obtained from an aspirator fitted to a laboratory filter pump. The air, at a pressure of about 4 inches of water, is passed consecutively through two tubes containing anhydrous calcium chloride, followed by two tubes containing "Carbosorb" soda-lime.

Alternatively, pure nitrogen from a cylinder may be used.

N/6.7 Sodium Hydroxide.

This is prepared and standardised in the usual way, and is kept in a $4\frac{1}{2}$ litre bottle protected with a soda-lime guard tube. A syphon tube leads directly to a 10 ml. burette.

Procedure.

10 mls. of the cider, which has been thoroughly de-gassed to remove CO_2 , is transferred to a 250 ml. conical flask and 100 mls. of indicator solution added. The solution will be bright yellow and the pH in the region of 3.5 to 4.0.

The contents of the flask are titrated with the standard caustic soda solution to the grey end-point; the appearance of the green colour indicates approaching neutrality.

During the titration, CO_2 -free air is passed into the solution *via* a suitable capillary tube at a rate sufficient to keep the solution well stirred, and to prevent the access of CO_2 from the air.

The titration is best carried out by the light of a daylight lamp in order to standardise the procedure and to be independent of the prevailing conditions of light.

The colour changes observed are listed below, together with the pH ranges in which they occur.

pH	Colour
3.0—6.0	Yellow
6.0—7.4	Pale green to dark green
7.4—8.0	Greenish grey to greyish purple
above 8.0	Full purple

As stated in the previous section, the true end-point is obtained in the range of pH 7.4 to 8.0, where the indicator registers grey. Provided CO_2 is excluded by continuing to pass the CO_2 -free air, the end-point is stable and the grey colour persists for several hours.

A minor improvement has been effected by performing the titration in a 4 oz. medicine bottle, in which the colour change can be observed through a uniform thickness of solution.

Summary.

The various methods available for the determination of the titratable acidity of cider are briefly discussed, and a new modification using a mixed indicator of Bromo-thymol Blue and Phenol Red is described. The validity of the method is shown by an examination of the pH/titration curves of three typical ciders.

The main advantage of the method is that a sharp and easily recognisable end-point is obtained, and interference from the natural pigments of the cider is eliminated.

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THE APPLE AS A SOURCE OF VITAMIN C. TESTS IN 1946.

By MARGARET E. KIESER and A. POLLARD.

In the Report for 1945 (1) it was pointed out that many of the common varieties of apple contained larger amounts of Vitamin C than had generally been assumed. The tests described have since been extended by analyses of a wider range of varieties of known origin and some of these results have already been published in brief form (2). The present account will give these results more fully and some storage tests of a few varieties will also be included.

Method of Analysis.

The fruit was analysed in the manner described previously, taking bulk samples of sectors cut from 2 to 3 lb. of fruit selected at random from a larger representative sample. The values found for the varieties are, however, only intended to be taken as indicating the general level of ascorbic acid in the fruit, for variations are to be expected according to the source, cultural treatment, season and maturity. In one experiment it was found that the values given by 5 lots of 3 fruits from a small block of trees of one variety ranged from 9.4 to 12.2 mg. ascorbic acid per 100 g. The mean of these values agreed closely, however, with the value found for a bulk sample made up of sectors cut from the same 15 fruits. It was thus assumed that a sample of about this size (15 fruits) would give a figure as reliable as would a larger number of small samples.

Results.

The amounts of ascorbic acid found in some culinary, dessert and cider fruit are shown in Table I, and they are expressed as mg. per 100 g. fresh fruit including skin. In Table II are shown the values found for a number of seedling varieties together with their parentage where known.

TABLE I.

Fruit							Ascorbic Acid mg./100g.
<i>Culinary.</i>							
Golden Noble	..	..	..	..	..	..	6.9
Edward VII	..	..	..	..	..	..	8.5
Early Victoria	..	..	..	..	..	..	10.8
Crawley Beauty	..	..	..	..	..	..	11.8
Newton Wonder	..	..	..	..	..	..	14.6
Arthur Turner	..	..	..	..	..	..	15.3
Lane's Prince Albert	..	..	..	..	..	..	15.4
Bramley's Seedling	..	..	..	..	..	..	22.3
<i>Dessert.</i>							
Miller's Seedling	..	..	..	..	..	..	7.9
Laxton's Superb	..	..	..	..	..	..	13.9
Cox's Orange Pippin	..	..	..	..	..	..	14.4
Allington	..	..	..	..	..	..	15.0
Ellison's Orange	..	..	..	..	..	..	15.5
Worcester Pearmain	..	..	..	..	..	..	16.0
Lord Lambourne	..	..	..	..	..	..	17.2
Blenheim Orange	..	..	..	..	..	..	18.4
Rival	..	..	..	..	..	..	22.5
<i>Cider.</i>							
Broadleaf Norman	..	..	..	..	..	..	7.7
Reine des Pommes	..	..	..	..	..	..	7.9
Ellis Bitter	..	..	..	..	..	..	9.3
Kingston Black	..	..	..	..	..	..	10.3
Foxwhelp	..	..	..	..	..	..	10.3
Cap of Liberty	..	..	..	..	..	..	12.1
Brown's	..	..	..	..	..	..	13.6
Court Royal	..	..	..	..	..	..	13.8
Kingston Black	..	..	..	..	..	..	13.9
Bulmer's Norman	..	..	..	..	..	..	14.0
Dufflin	..	..	..	..	..	..	15.6
Medaille d'Or	..	..	..	..	..	..	16.0
Northwood	..	..	..	..	..	..	16.1
Chisel Jersey	..	..	..	..	..	..	16.3
Doux Amere	..	..	..	..	..	..	16.9
Sweet Coppin	..	..	..	..	..	..	17.0
Knotted Kernel	..	..	..	..	..	..	18.1
Dabinett	..	..	..	..	..	..	18.7
Sherrington Norman	..	..	..	..	..	..	20.4
Stoke Red	..	..	..	..	..	..	20.5
Eggleton Styre	..	..	..	..	..	..	20.5
Hangdown	..	..	..	..	..	..	20.7
Tremlett's Bitter	..	..	..	..	..	..	20.9
Tardive Forestier	..	..	..	..	..	..	23.3
Frederick	..	..	..	..	..	..	26.2
Sweet Alford	..	..	..	..	..	..	30.7
Medaille d'Or (Upright)	..	..	..	..	..	..	31.1
White Jersey	..	..	..	..	..	..	31.7
Yarlington Mill	..	..	..	..	..	..	39.0

It will be noted that the figures range from about 7 to over 20 mg. in all classes of fruit, but the cider varieties reach the highest levels. The values given by some of the dessert varieties in 1946 are much higher than those found in 1945 (*e.g.* 14.4 mg. for Cox in 1946 as against 5.7 in 1945). Some of

TABLE II.
ASCORBIC ACID IN SEEDLING APPLES.

Variety	A.A. mg./100g. whole fruit	Parentage	Types*
Worcester Cross	5.9	Cox x Wealthy	D
BB.4 (1)	8.4	Beauty of Bath x ?	D
Taunton Cross (2)	8.5	Wealthy x ?	D
Hereford Cross	9.5	Cox x ?	D
G.M.R.7	9.5	James Grieve x Mackintosh Red	D
Newport	10.1	Devonshire Quarrendon x Cox	D
TXSP	13.3	Taunton Cross sport	D
C.WY.1	15.3	Cox x Wealthy	D
K.41	17.2	Bismark x ?	C
F.12	18.4	Frogmore Prolific x ?	C
Y.4	19.0	Lord Derby x ?	C
W.R.L.28	22.3	Worcester x Rival	D
M.C.10	24.0	Mother x Cox	D
Y.K.1	25.5	Lord Derby x Bismark	C
F.18	26.2	Frogmore Prolific x ?	C
C.BB.2	27.0	Cox x Beauty of Bath	D

* Dessert (D) or Culinary (C).

(1) stored 10 days.

(2) stored 22 days.

this difference may be due to differences in maturity at the time of picking or to the fact that in 1945 the fruit was analysed a short time after picking. whereas in the later season it was analysed immediately. Some of the cider varieties show similar discrepancies between the two seasons. Certain varieties have consistently shown high values, notably Bramley's Seedling, while in the cider varieties Yarlington Mill has given the highest value in both seasons of test. Some of the seedlings, both of culinary and dessert types, have surpassed the older varieties in their ascorbic acid contents, and it will be of interest to see if this is maintained in subsequent years. It is not possible to detect any obvious relation between the level of ascorbic acid in the seedlings and that in their parents. The values for many of the parents are not known and also seedlings with the same parentage such as Worcester Cross and C.WY.1 give fruits with widely differing values; furthermore, only a few of the seedlings of any given parentage were available for testing.

The Effect of Storage.

Conflicting results have been reported for the loss of ascorbic in stored apples, *e.g.* Jennerup (3) described small losses in fruit of many varieties stored from October to March. American workers (4) on the other hand found rapid losses on storage even for a few weeks at 3°C., although fruit left on the tree for the same time showed little change. Some preliminary tests on storage carried out here will be briefly described.

Fruit from two given trees of Yarlington Mill and Frederick was picked before maturity, stored at room temperature and samples were taken for analysis at intervals of 5 days. On the same days, fruit was picked from the trees and analysed immediately. In Table III are shown the values for ascorbic acid in the whole fruit and in the skin and pulp portions. As found in the earlier tests, the concentration in the skin is much higher than it is in the pulp; the variations found in the skin portion are, however, no doubt largely due to the difficulties of obtaining uniform peeling.

TABLE III.
 ASCORBIC ACID (MG./100G.) IN CIDER APPLES MATURED ON AND OFF THE TREE.
 YARLINGTON MILL.

Day	Fresh			Stored		
	Whole Fruit	Skin	Pulp	Whole Fruit	Skin	Pulp
1	31.8	98.4	27.6			
5	35.3	74.4	24.6	40.7, 42.3	66.0	27.1
10	34.4	104.0	24.4	36.7	84.6	35.2
15	35.8	103.3	29.5	35.8	64.4	26.9
46 (as milled)				31.6	72.2	18.7

FREDERICK.

Day	Fresh			Stored		
	Whole Fruit	Skin	Pulp	Whole Fruit	Skin	Pulp
1	17.4	64.5	12.1			
5	21.6	64.6	15.9	15.0	45.1	10.0
10	18.8	63.7	12.4	14.6	44.8	8.4
15	21.9	67.2	14.5	13.9	41.8	7.7

The fruit of Yarlington Mill shows little consistent change in the first two weeks whether stored or left on the tree, but at the time of milling six weeks later, the stored fruit shows some loss of ascorbic acid. The early maturing variety Frederick shows a more definite loss, and after two weeks the stored fruit has only about 60% of the ascorbic acid in fruit left on the tree. There thus appears to be some relation between the retention of ascorbic acid and the onset of maturity. This is also shown by some tests of stored Bramley's Seedling and Cox's Orange Pippin. In the former variety there was no appreciable loss when tested in March, although the Cox had already lost 50% of the original ascorbic acid in the previous December.

A more comprehensive storage test was carried out on the two varieties Allington and Edward VII which had been used by another member of Staff for tests on the effect of synthetic growth substances on stored fruit. The fresh fruit was obtained from a manurial plot where replicate blocks of the two varieties had received N and NPK fertiliser treatments. At the time of testing it was only possible to obtain a bulk figure for the initial ascorbic acid in the Allington, but a more accurate figure was obtained for the Edward VII by sampling each block separately. The values found for the two fertiliser treatments are shown in Table IV, where it is seen that, although there is considerable variation between replicates, the mean value for the N treatment is significantly higher than that for the NPK treatment (significant difference 1.46 for $P = 0.05$).

TABLE IV.		
Treatment :	N	NPK
	10.9	8.6
	11.5	10.0
	13.2	9.2
	12.8	11.0
	11.4	9.3
Mean	11.96	9.62

As will be shown below, this relative difference between the two treatments was also found subsequently in the stored fruit.

The stored fruit was analysed in January when the Edwards were still in excellent condition and when the Allingtons were over-mature and showing considerable storage damage. The Edwards were again analysed in March, when they were still in good condition. The differences in the ascorbic acid content of the batches due to the growth substances were small and these results will therefore not be given in detail. The only noticeable effect was a slightly lower ascorbic acid where ripening had been hastened or where scald damage was seen; the control fruits showed the best retention. The average values for ascorbic acid in the two varieties from the two manurial blocks are given in Table V, where the fruit from the N block still shows a higher value than that from the NPK block.

TABLE V.

Allington	..	Initial value (approx.)	N	NPK
			15.0	
		January	6.5	5.2
Edward VII	..	Initial value	12.0	9.6
		January	5.8	4.8
		March	5.6	4.4

It will be seen that the retention of ascorbic acid in the Edward at the January testing was about 5% higher than that in the Allington; also the Edward showed only a slight further loss in the following three months.

Ascorbic Acid in Pears.

The effect of maturity on ascorbic acid content is shown even more strikingly by some tests of pear varieties. The amount of ascorbic acid in pears has been assumed to be even lower than in apples (cf. Olliver (5)) and to amount to about 3 mg. per 100 g. The values found in these tests for ripe pears are shown in Table VI, and they are seen to be of this order although in the unripe fruit as picked the values may be much higher. These results therefore suggest that the pear in eatable condition is a poorer source of ascorbic acid than the apple.

TABLE VI.

ASCORBIC ACID IN PEAR VARIETIES (mg./100g.).

Variety					As Picked	Ripened
Durondeau	..	..	..	..	6.9	
Louise Bonne	..	..	..	..	7.3	
Beurre Hardy	..	..	..	..	8.7	4.2
Doyenne du Comice	..	..	..	..	9.4	
Bristol Cross	..	..	..	..	9.4	6.6
William's Bon Chretien	..	..	..	..	11.0	3.8
Beurre Bedford	..	..	..	..	12.0	4.1
Beurre Superfin	..	..	..	..	12.2	
Conference	..	..	..	..	13.4	
Jargonelle	..	..	..	..	—	3.4

The Effect of Cooking.

Tests on cooked and fresh fruit carried out by Olliver (1.c.) showed that apples of fairly low ascorbic acid content retained about half the vitamin on cooking. As some varieties have now been found much higher in ascorbic acid, it was thought to be of interest to determine the effect of stewing and baking on such a variety. Representative samples were therefore taken from a bulk of Bramley's Seedling and cooked in the usual manner. The results are given in Table VII, where the values for the pulp are shown after correction for the effects of evaporation or of dilution during cooking.

TABLE VII.

	Ascorbic Acid (mg./100g.)
Fresh pulp	15.5
Pulp stewed with sugar	9.9
Pulp stewed without sugar	8.4
Baked whole fruit	9.7 (in pulp)
Baked cored fruit	10.2 „

The amount of ascorbic acid in the cooked fruit is thus seen to be about 55—65% of that originally present. Tests for interfering substances showed that the figures represented true ascorbic acid and that the cooking operations had not produced any appreciable amount of other reducing substances.

SUMMARY.

1. Tests carried out on apple varieties during 1946 have shown that some of these may contain considerable amounts of Vitamin C, the values found for some varieties being higher than in the previous year.

2. In general the cider varieties reach the highest level, but a few of the culinary and dessert types may approach this.

3. The loss on storage is more pronounced in the early maturing varieties than in those with better keeping qualities.

The loss of Vitamin C on ripening is more rapid in pears.

4. The amount of Vitamin C retained in cooked apples is from about a half to two-thirds of that present originally.

ACKNOWLEDGMENT.

We wish to acknowledge the assistance of Mrs. J. Tolhurst in the analytical work.

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THE ORGANIC ACIDS OF SOME COMMON FRUITS.

By JOAN D. BRYAN.

Estimations of the total acidity in fruits are frequently published, giving the ranges of acidity and the pH values. The information as to the nature of the acids present is, however, sparse and contradictory. The earlier analyses were often carried out by methods of doubtful specificity and the variety of fruit used was not always stated. The more recent methods, such as those of Pucher and Vickery (1), which were originally developed for leaf analyses, have not been used extensively for the analysis of fruits. In work on fruit juices and similar products it is an advantage to know which of the common acids is present in quantity, as for example in experiments on methods of acid removal. This was brought out in the past by work on plum processing, where the acid present was found to be mainly malic acid, although in tables it is often given as "citric." To obtain further information on the subject some preliminary tests have been made on the acids present in fruits of known varieties, and these will be described.

Methods.

Large fruits were sampled by taking sections of pulp from a number of fruits; small fruits were sampled whole after removal of the stalks. 70 g. of this material was ground in a Waring Blendor with an equal weight of water and 120 g. of the pulp so obtained, equivalent to 60 g. of the original fruit, was weighed into an evaporating basin. After drying overnight at 70°C. the final weight of the residue was about half that of the fresh fruit. 10 g. portions of this concentrate were weighed out for Soxhlet extraction with ether in the manner described by Pucher and Vickery (1); the improved method of extraction described by Isherwood (2) was not available at the time. Determinations of total acidity, and of malic, citric and oxalic acids were carried out on the ether extract by the methods described by these authors (1).

Results.

The amounts of the three acids found in five species of fruit and in rhubarb are given in the Table, and they are expressed as milli-equivalents per 100g. fresh fruit (1 milli-equivalent of malic acid = 0.067%). The organic acid in plums and apples is seen to be almost entirely malic acid as already observed by Hartmann and Hillig (3). In gooseberries and tomatoes citric and malic acids are present in similar quantities, but in the black currant varieties tested citric acid predominates. Hartmann and Hillig (3) found that citric acid was the main acid present in currants (variety not stated), but they also found mainly citric acid in tomatoes whereas the present results suggest a considerable proportion of malic acid in the latter fruit. Rhubarb alone contains an appreciable amount of oxalic acid, the relative concentrations of the three acids being in the order; malic, oxalic and citric. This is in agreement with the results of Pucher, Vickery and Wakeman (4) for the acids of rhubarb petioles.

In the fruits tested, the citric and malic acids make up the greater part of the total acidity, although other acids are no doubt present in small amounts. It is evident that there may be considerable variation in the relative proportions of citric and malic acids in a given species in addition to variations

ORGANIC ACIDS IN FRUITS AND RHUBARB.

Fruit	Variety	Condition of fruit	Milli-equivalents/100 grams. of Fruit.				
			Total Organic Acids	Malic Acid	Citric Acid	Oxalic Acid	Malic + Citric + Oxalic
Gooseberry	Keepsake	Green and unripe	29.50	11.9	14.6	0.1	26.6
	Whinham's Industry	"	{ 28.9 32.0	11.0 11.9	11.9 11.3	0.4 0.3	23.3 23.5
	Leveller	"	22.7	7.8	11.4	negligible	19.2
Plum	Edward Walker II	Ripe (sweet)	{ 24.2 24.6	22.7 22.3	0.3 0.3	0.1 0.1	23.1 22.7
	Monarch	Ripe (sour)	{ 30.1 31.6	29.0 29.4	0.2 0.3	negligible	29.2 29.7
	Vetomold	Ripe	{ 13.2 12.8	4.5 3.9	6.0 6.0	— 0.1	10.5 10.0
Apple	Bramley Seedling	Kept in cold store	{ 18.5 19.2	14.6 15.7	0.3 0.3	0.1 0.1	15.0 16.1
	Cotswold Cross	Stored in alcohol	{ 38.6 42.4	3.9 3.9	32.3 35.6	0.5 0.6	36.7 40.1
Rhubarb	Mendip Cross	"	{ 39.9 42.8	8.9 8.9	28.6 31.0	0.3 —	37.8 39.9
	Unknown	Forced	{ 20.5 23.7	11.9 15.6	1.7 1.9	3.4 4.2	17.0 21.7

in total acid content ; but further analyses on a wider range of varieties are required before more definite conclusions can be drawn.

The writer is indebted to Dr. A. Pollard for suggesting this work.

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PROGRESS REPORT ON DOMESTIC APPLE JUICE PRODUCTION.

By ALICE CRANG, DILYS JAMES and MARGARET STURDY.

INTRODUCTION.

In a preliminary report on the production of apple juice on a domestic scale (1) it was noted that further work was required on methods of preventing the formation of a deposit during storage. The results of this further work are given below.

EXPERIMENTAL.

Varieties used.

Bramley's Seedling, Edward VII and Crawley Beauty apples were pressed in December 1945, and Bramley's Seedling, Edward VII and Allington Pippin between October 1946 and March 1947. All apples were stored in boxes in a cool room until pressed.

Extraction.

Previously the methods used to extract the juice were substitutes for mechanical presses. In these experiments a small hand fruit press was used. "The Lumley Press" consists of a plunger fitted to a screw on a stand, a slatted cylindrical wooden cage and a flat wooden tray. The minced apple pulp is put in a cloth bag inside the wooden cage which is placed in the tray at the base. A basin is put at the grooved end of the tray to collect the juice. The plunger is then slowly screwed down on the bag so that the juice exudes down the cylinder into the tray and out to the basin, the pulp being pressed into a cake in the bag.

The fruit was pressed once, the cake was then macerated with water (2) and pressed again. The colour, viscosity and yield of juice varied with the

ANALYSIS OF THE THREE JUICES BEFORE TREATMENT.

	Specific Gravity	Acidity as Malic Acid %	pH
Bramley's Seedling	1.045	0.94	3.20
Edward VII	1.039	0.89	3.24
Crawley Beauty	1.036	0.44	3.40

variety and maturity of the apples, but generally this method gave a good yield.

14 lb. apples with 1 pint of water added for the second pressing gave a total of 6-7 pints of juice (the average cider press yield is 160-170 gals./ton or 8 pints per 14 lb.).

Palatability of the unclarified juices.

The unblended juices were tested for flavour after three to six months' storage. Allington Pippin gave a good flavoured, palatable product. Bramley's Seedling was poorer than the above but not unpleasant and more acid than the other varieties. Edward VII juice was sweeter than the Bramley, and rather more pleasant. Crawley Beauty was unpalatable, being too sweet and not sufficiently acid.

Undoubtedly the best flavoured drink is one in which the acid variety is blended with the sweet. A mixture of Bramley's Seedling and Edward VII gave a pleasant drink. For the purpose of this investigation on clarifying the juices, no blends were bottled for storage.

Clarification.

The juice obtained requires filtering before bottling. After the juice is strained through a filter cloth or jelly bag to remove the pulp, bottled and sterilised, the colloidal stability of the juice may undergo a change. When this happens the appearance of the juice is spoilt by the formation of either a thick suspension or a heavy sediment. The prevention of sediment, and the desire to obtain a clear juice has occupied the attention of many workers with varying results, and there is a great deal of contradictory literature on the subject. Commercially, sediment formation has been overcome by the use of a Seitz filter, when a clear sparkling juice is obtained with little difficulty, but as this cannot be used as a domestic method, attempts were made either to obtain a juice which, though hazy, would not form a sediment on storage; or preferably, to precipitate the colloidal material before bottling the juice.

In order to facilitate filtering after pressing, the usual practice is to add a depectinizing enzyme. The enzyme used here was "Pectinol A." The time during which the juice should stand with the enzyme before filtering depends on the amount of enzyme, the temperature of the juice and the variety and ripeness of the apples (3).

Pectinol was added at the rate of 1 oz./5 gals. and left for 18 hours at room temperature (50-60°F), the juice was allowed to drip through a jelly bag, then bottled and pasteurised as in treatment 3, Table I.

A filter aid is also recommended (3) to clarify the juice, and some juices were mixed with "Filtercell" $\frac{1}{4}$ oz. to 4 pints and strained through a felt jelly bag, others were treated with "Pectinol" first (4).

Several writers have reported success when pectin has been added to the clarified juice, but the results reported by Neubert and Veldhuis (4) were not very definite. The variation from batch to batch seems very great. Experiments on the domestic scale, as summarised in Table I, agree with these findings.

It will be seen that none of the three varieties gave consistent results, but the variety Crawley Beauty gave the darkest and cloudiest juice throughout.

During these experiments it was found that pressed juice from Allington Pippin gave a brilliantly clear product when filtered through either felt or silk in early October, but a cloudy product when pressed and filtered in December

TABLE I.

Treatment	Clarity of the Juice after Storage		
	Bramley's Seedling	Crawley Beauty	Edward VII
1. Control : pressed & filtered through jelly bag	2 bottles clear with $\frac{1}{2}$ " deposit. 2 bottles cloudy	Cloudy with slight deposit	Slightly cloudy. 1 bottle clear with $\frac{1}{4}$ " deposit
2. "Filtercell" in jelly bag	All cloudy, slight deposit	Cloudy with slight deposit	Cloudy, slight deposit. 1 bottle clear with $\frac{1}{4}$ " deposit
3. "Pectinol A" for 18 hrs. and filtered through jelly bag	3 bottles cloudy and slight deposit. 1 bottle clear with $\frac{1}{2}$ " deposit	Cloudy with slight deposit	1 bottle slightly cloudy. 1 bottle clear with $\frac{1}{4}$ " deposit
4. "Pectinol A" for 18 hrs. and "filter-cell" in jelly bag	All cloudy with slight deposit	1 bottle thick scum, 1 bottle clear. 2 bottles cloudy with slight deposit	Slightly cloudy, slight deposit
5. "Pectinol A" for 18 hrs. filtered through jelly bag. 10g. Pectin added to 2 pints juice	2 bottles cloudy, slight deposit. 1 bottle clear $\frac{1}{2}$ " deposit. 1 bottle clear $\frac{1}{4}$ " deposit and scum	1 bottle thick scum and clear. 2 bottles cloudy with slight deposit	1 bottle slightly cloudy. 2 bottles clear with slight deposit
6. "Pectinol A" for 18 hrs. "Filtercell" in jelly bag and 10g. Pectin added to 2 pints juice	All cloudy and slight deposit	Cloudy, slight deposit	2 bottles very slight haze and slight deposit

and January. Some tests on fresh Allington Pippin and Edward VII juices gave different results from Crawley Beauty juice bottled the previous year and from pressed juice from Bramley's Seedling pressed in February.

It was thought that slight traces of hard water on the inside of the bottles might have caused the discrepancies between bottles of one batch, therefore attempts on a small laboratory scale were made to precipitate the colloid before bottling. On the whole the addition of alkalis, acids and electrolytes cleared the juices with varying degrees of success but the fresh apple flavour of the juice was entirely lost. Isinglass in nearly all cases gave a poor flavoured product and much of the colour was lost. Crushed egg shells were tried with negative results and when commercial egg albumen was used as a clarifying agent, the juice cleared but lost all its colour and the smell and flavour were distinctly objectionable. These methods are tabulated in Table II.

As stated by Tressler et al "The gelatin-tannin process is the most widely used colloid precipitation process for clearing fruit juices, but since the chemical reaction involved must be accurately adjusted for each juice and each type of gelatin used, considerable time and experience are necessary in making the required tests." (3) The method is, therefore, unsuitable for domestic use and was not employed.

Other agents and methods tried without satisfactory results were :—

Borax.	Calcium Chloride.
Casein.	Magnesium Sulphate.
Gelatin in Water.	Ferrous Chloride.
Tartaric Acid.	Filtration with "Filtercell."

TABLE II.

Treatment	Variety	Colour	Flavour	Clarity
0.1g. Isinglass + 0.1g. citric acid in $\frac{1}{2}$ pt. juice, left 48 hours and filtered	Edward VII Allington Pippin Bramley's Seedling	Amber " "	Fairly good lost freshness " "	Slightly Cloudy Cloudy "
1g. Isinglass + 1g. citric acid in 450ml. juice	Edward VII Bramley's Seedling	Light- Amber Amber	Flat Good	Brilliant Not Clear
3.4g. NaHCO_3 in 450ml. juice giving pH 6.0, heat to 190°F. Add 3.2g. tartaric acid, filter (pH 4.1 and original colour)	Edward VII Crawley Beauty Bramley's Seedling Allington Pippin	Amber " " "	Acid, otherwise good Very poor Poor "	Brilliant Cloudy Slightly Cloudy " "
4.5g. NaHCO_3 in 450ml. juice. Heat to 170°F, add 6.9g. citric acid (pH of juice 4.2)	Allington Pippin Bramley's Seedling	Brown "	— —	} No deposit after standing over night
CaCO_3 added to 10ml. juice, shaken, citric acid added	Crawley Beauty Allington Pippin Bramley's Seedling	Golden " "	Fairly good " " "	
CaCO_3 added to pH 6.0 + tartaric acid to pH 4.2 " " " " " " "	Bramley's Seedling " " " " " "	" " " " " "	Very poor " " " " " "	Not Clear " " " " " Clear at once

Sodium Tartrate.	Filtration through organdie.
Sodium Chloride.	Filtration through silk after addition of crushed egg shell.
Calcium Carbonate.	Electrophoresis.

None of the above precipitated the colloid material.

Ammonium Sulphate cleared the juice, but the resultant juice was unpalatable. Gelatine caused loss of colour on heating. Gelatine and alum or gelatine and calcium carbonate caused some precipitation of the colloids.

A worker in Germany in October 1946 was using the following method which he claimed to be very good and rapid. "Pectinol A" was added at the rate of $\frac{1}{4}\%$ to the juice and heated to 60°C ., a handful of asbestos to a bucket of juice was then added and the juice repeatedly filtered through a cloth until clear. When tried in the laboratory the flavour of the juice obtained by this method was very poor. "Filtercell" was added instead of asbestos, using 2 tablespoons "Filtercell" to 2 litres Allington Pippin juice, which was allowed to drip through a jelly bag. After 24 hours a hazy juice with good flavour was obtained, and juice filtering for 24-72 hours was brilliantly clear with a good flavour.

The method was repeated with Bramley's Seedling juice using 2 tablespoons "Filtercell" to 3 litres juice. After one hour the juice dripping through was clear and all the first juice was refiltered. After 24 hours $1\frac{1}{2}$ litres were bottled. After 72 hours a further $\frac{1}{2}$ litre had filtered but a very high proportion, one-third, had been lost in evaporation, or not dripped through.

Juice from Edward VII apples, using 2 litres of juice and 1 tablespoon "Filtercell," gave similar results. These juices are now being stored together with untreated juices.

The length of time for which the juice and Pectinol should stand at this temperature for rapid results has not yet been determined. Further investigations are in progress with regard to these problems. A quicker method of filtering on a small scale will also have to be tried.

Summary.

Attempts have been made to prevent a deposit forming in apple juice either by stabilizing or breaking down the colloidal system in the juice before storage. A number of materials are effective for this purpose, but their use spoiled the flavour.

The method of using a depectinising enzyme at a moderately high temperature, followed by a filter aid is promising and is still under investigation.

The extracts pressed from fresh apples gave less cloudy and more easily cleared juices than pressings from apples which had been stored for a few months. This is of interest, as it may partly explain inconsistent results of clarification methods obtained here and by other workers. It is being studied more fully.

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THE RETENTION OF ASCORBIC ACID AND RIBOFLAVIN IN PRESERVED VEGETABLES.

By ALICE CRANG, DILYS JAMES and MARGARET STURDY.

INTRODUCTION.

Three vegetables, beans, peas and swedes, have each been preserved by canning and bottling, using steam pressure for sterilizing the cans and one series of bottles, and three hours' boiling for the other bottles. These have been tested after short and prolonged periods of storage for the amounts of ascorbic acid and riboflavin retained. The samples stored some months were also reheated as for serving, to give the quantity of ascorbic acid which would normally be consumed.

INVESTIGATION.

Preparation of Vegetables.

Beans : Scarlet Runner beans were picked and stringed, stored overnight at 4°C., sliced by machine, analysed and processed the day after picking. Each jar was packed with 250 g. of beans and 210 ml. of boiling brine (made from 2 oz. salt per gallon of water), and each can with 275 g. of beans and 270 ml. of brine. The beans for each container were weighed out after slicing, blanched 1 min. in 3 pt. of boiling water, dipped in cold water 15 secs., and drained well before packing into the container.

Peas : The variety Onward was used. The peas were picked and shelled one day, left overnight in a cool store, processed and analysed the following day. Each jar was packed with 320 g. of peas and 185 ml. of boiling brine (made from 2 oz. salt and 40 g. sugar to each gallon of water) and each can with 350 g. peas and 200 ml. brine. The peas for each container were weighed out, blanched 2 min. in boiling water and dipped 15 secs. in cold water.

Swedes : The roots were stored 3 days at room temperature before preparation. They were scrubbed, peeled and a longitudinal wedge taken from each swede for analysis. The remainder was diced and bulked for processing. For each jar 350 g. swede and 160 ml. boiling brine (made from 2 oz. salt per gallon of water) were used and 375 g. swede and 220 ml. brine for each can. Each lot of swedes was weighed out, blanched 2 mins. in 3 pt. of boiling water and dipped 15 secs. in cold water.

Processing.

(a) 1 lb. screw-band preserving jars were used. The filled jars were processed for 35 mins. at 10 lb. steam pressure.

(b) Similar jars were used and processed for 3 hours in boiling water.

(c) A2 cans were used, exhausted in water at 180°F. for 5 mins. before sealing, and processed for 35 mins. at 10 lb. steam pressure.

There was considerable loss of liquid from method (a) and some loss from method (b). These losses have been allowed for in estimating the percentage ascorbic acid and riboflavin retained in the containers.

Storage.

The jars and cans were stored together at room temperature in semi-darkness.

Cooking.

Part of each sample stored for some months was reheated in the proportions present in the container. The weighed sample was put in a covered glass beaker standing in cold water which was brought to the boil and boiled for 5 mins.

Method of Estimating Ascorbic Acid.

As there is a likelihood of reducing substances being formed in vegetables on processing at high temperatures, which will react in the same way as ascorbic acid when titrated against 2:6 dichlorophenol indophenol, the procedure used in all cases was the determination of the "apparent" ascorbic acid, as given by the usual titration methods, as well as the "real" ascorbic acid, in which the reductones present are deducted from the former, using Mapson's method (1).

Method of Assaying Riboflavin.

The method of microbiological assay was used and the technique employed for fruit (2) was found to be satisfactory for vegetables.

RESULTS.

The ascorbic acid and riboflavin contents of the fresh vegetables were as follows:—

TABLE I.

Vegetable	Ascorbic Acid mg/100g.		Riboflavin μ g./100g.
	"Real"	"Apparent"	
Beans	20.7	21.5	0.91
Peas	17.5	19.0	2.68
Swedes	26.3	33.0	0.42

Tables II to IV give the "real" and "apparent" ascorbic acid contents in 100 mg. of the preserved vegetable and brine, in the proportions found on opening the container. As there was considerable loss of contents on processing, especially in method (a), the ascorbic acid retained in each container after storage has also been given as a percentage of that in the weight of vegetable packed into the jar before processing.

TABLE II.
BEANS.

Processing Method	Average Length of Storage	Contents		“ Real ” Ascorbic Acid		“ Apparent ” Ascorbic Acid	
		Solid	Liquid	mg/100g.	% retained	mg/100g.	% retained
a	17 days	g. 200	g. 183	4	29	6	43
”	”	210	174	5	36	7	54
b	”	225	169	3	22	5	37
”	”	218	197	7	53	9	74
c	”	240	314	2	22	5	47
”	”	248	303	3	30	6	58
a	19 months	227	141	1	10	3	18
”	”	232	142	2	14	4	24
b	”	239	186	1	9	3	20
”	”	238	178	nil	nil	1	9
c	”	274	278	2	16	5	50
”	”	271	278	1	13	4	38
a reheated	”	227	141	nil	nil	0.7	5
b ”	”	239	186	nil	nil	0.5	4
” ”	”	238	178	nil	nil	0.5	4
c ”	”	274	278	nil	nil	2.6	24
” ”	”	271	278	nil	nil	1.4	13

TABLE III.
PEAS.

Processing Method	Average Length of Storage	Contents		" Real " Ascorbic Acid		" Apparent " Ascorbic Acid	
		Solid	Liquid	mg/100g.	% retained	mg/100g.	% retained
a	4 days	^{g.} 290	^{g.} 64	4	27	8	46
"	"	292	55	4	24	6	33
b	"	304	103	5	37	8	54
"	"	316	107	4	30	5	38
c	"	349	196	4	38	7	57
"	"	348	198	6	51	8	65
a	20 months	239	58	4	25	6	41
"	"	279	58	4	26	7	37
b	"	316	91	5	36	7	49
"	"	329	80	5	39	7	47
c	"	356	194	5	46	7	58
a reheated	"	239	58	3	15	4	25
" "	"	279	58	3	15	4	22
b "	"	316	91	4	28	6	37
" "	"	329	80	3	22	5	32
c "	"	356	194	4	33	6	48

TABLE IV
SWEDES.

Processing Method	Average Length of Storage	Contents		“ Real ” Ascorbic Acid		“ Apparent ” Ascorbic Acid	
		Solid	Liquid	mg/100g.	% retained	mg/100g.	% retained
a	10 days	g. 303	g. 56	7	26	11	34
”	”	315	45	6	23	8	24
b	”	322	108	6	27	9	35
”	”	316	114	7	33	10	37
c	”	355	218	3	18	6	29
”	”	350	219	6	32	10	37
a	18 months	304	51	2	8	4	11
”	”	306	48	2	6	3	9
b	”	320	140	0.6	3	2	8
”	”	323	124	2	10	4	14
c	”	356	212	4	22	7	31
”	”	351	214	1	7	3	14
a	”	304	51	< 0.7	< 2	0.8	2
”	”	306	48	< 0.5	< 2	0.6	2
b	”	320	140	< 0.2	< 1	0.2	1
”	”	323	124	< 0.5	< 2	0.6	2
c	”	356	212	< 0.6	< 3	1.7	8
”	”	351	214	< 0.7	< 3	1.4	6

Tables V to VII give the riboflavin content of the preserved vegetables and their liquors after different lengths of storage. In some cases solids and liquids were assayed separately and in others together in the proportions found on opening the container. The total riboflavin in each stored container is also given as a percentage of that originally present.

TABLE V.
BEANS.

Processing Method	Average Length of Storage	Contents		Riboflavin retained in :—			
		Solid g.	Liquid g.	Solid $\mu\text{g/g.}$	Liquid $\mu\text{g/g.}$	Solid + Liquid $\mu\text{g/g.}$	Total Contents % original
a	28 days	210	174	0.5	0.32	—	71 (i)
b	"	218	197	0.5	0.42	—	77 "
c	"	248	303	0.5	0.40	—	87 "
a	19 months	230	141	—	—	0.32	51 (iii)
b	"	239	182	—	—	0.44	82 "
c	"	273	278	—	—	0.46	81 "

TABLE VI.
PEAS.

Processing Method	Average Length of Storage	Contents		Riboflavin retained in :—	
		Solid g.	Liquid g.	Solid + Liquid $\mu\text{g/g.}$	Total Contents % original
a	4 days	291	60	1.64	62 (ii)
b	„	310	105	1.60	76 „
c	„	348	197	1.29	75 „
a	20 months	259	58	0.81	33 (iii)
b	„	323	86	1.07	51 „
c	„	341	191	1.13	64 „

TABLE VII
SWEDES.

Processing Method	Average Length of Storage	Contents		Riboflavin retained in :—			
		Solid g.	Liquid g.	Solid $\mu\text{g/g.}$	Liquid $\mu\text{g/g.}$	Solid + Liquid $\mu\text{g/g.}$	Total Contents % original
a	14 days	315	45	0.26	0.17	—	59 (i)
b	„	316	114	0.30	0.22	—	81 „
c	„	350	211	0.35	0.22	—	90 „
a	18 months	305	47	—	—	0.21	51 (ii)
b	„	321	132	—	—	0.20	60 „
c	„	353	213	—	—	0.20	72 „

- (i) Result on single jar or can.
- (ii) Arithmetic mean of results on duplicate jars or cans.
- (iii) " " " " triplicate " Difference between replicates $< 10\%$.

DISCUSSION.

The figures obtained on the bottled and canned vegetables show that the "apparent" ascorbic acid is about $1\frac{1}{2}$ times the value of the "real" ascorbic acid and in some cases there is no "real" ascorbic acid at all in spite of a value obtained by the usual direct titration method. The proportion of reductones present, giving the difference between the values of the "apparent" and "real" ascorbic acid, is small in fresh beans and peas, but larger in the fresh swedes.

There is considerable loss of ascorbic acid in the preparation and processing of each of the vegetables but no difference between the methods used if the results are based on mg./100g. of the preserved vegetable and brine. However, owing to considerable loss of contents when the bottled vegetables are steam-heated above boiling point, and some loss when boiled for three hours, the amount of ascorbic acid retained in each container is generally less in the bottled than in the canned vegetables.

There is considerable loss of ascorbic acid in the bottled or canned sliced beans and diced swedes during storage but no loss in the peas during the period 4 days to 20 months' storage.

When the stored vegetables have been reheated (as for general use), there is virtually no "real" ascorbic acid left in the beans or swedes, but there is some in the peas. The figures for "apparent" ascorbic acid as generally given in literature are misleading, especially in the canned vegetables.

Although vegetables are not a rich source of riboflavin and the amounts present in beans and swedes are very small, peas would provide an appreciable quantity of the daily requirement.

Between 65 and 85% of the total riboflavin retained in each container appears to be in the vegetable. The loss of riboflavin during preparation and processing was similar in the three methods used, when based on $\mu\text{g./g.}$ of vegetable and brine, but again there was greater total loss from the bottles than the cans, due to loss of liquid from the former in processing.

During storage of 18-20 months there was a definite loss of riboflavin in the peas and swedes, but not in the beans.

SUMMARY.

1. Ascorbic acid and riboflavin have been determined on bottled and canned beans, peas and swedes during storage.

2. Considerable loss of ascorbic acid occurred in all vegetables during processing, but thereafter there was little destruction in peas during 20 months' storage, but further losses occurred in the sliced beans and diced swedes.

3. The proportion of "reductones" present is small in the fresh beans and peas but is about $\frac{1}{4}$ of the "apparent" ascorbic acid in swedes. After processing, the "reductones" increased especially in the beans and peas so that they accounted for about $\frac{1}{3}$ of the "apparent" ascorbic acid in the preserved material.

4. The quantity of ascorbic acid left in the beans and swedes reheated after storage was negligible, but the retention in the peas was better.

5. There was some loss of riboflavin in processing the vegetables, and further losses during storage of the peas and swedes, but not of the beans.

6. The different temperatures of processing, and the use of glass as against metal containers had no effect on the ascorbic acid and riboflavin contents of the vegetables, apart from the loss of liquid on processing which occurred in the bottles and not in the cans.

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A NOTE ON BOTTLED CUCUMBERS.

By ALICE CRANG, DILYS JAMES and MARGARET STURDY.

Brine fermented cucumbers need careful control of the fermentation and temperature, and are not a very popular product in this country. The following tests were made to determine the acidity required for safe bottling of ridge cucumbers to give palatable products after storage.

Experimental.

Small whole ridge cucumbers were used, packed into 1 lb. preserving jars with proportions of cucumber to liquid varying from 1/2.5 to 1/0.9 and processed by placing in a warm water bath, bringing the water to the boil and boiling for 1½ hours.

The first series A was filled with a brine made of 5% vinegar diluted 1 in 5, and 2 oz. salt/gal. giving a pH value of 3.2. The second series B was filled with 5% vinegar diluted 1 in 10 and fortified with 0.5% citric acid and 2 oz. salt/gal. giving a pH value of 2.6. The pH value of the brine was determined again 17 hours, 10 days and 12 months after processing.

The cucumbers were tasted for flavour and texture at each opening. The results were as follows :—

The brine having original pH value of 3.2 varied between 3.5 and 4.0 after storage, and that having original pH value of 2.6 varied between 3.1 and 3.7, according to the different proportions of cucumber to brine used. These brines are sufficiently acid for safe processing under the conditions used.

The texture was good in all cases, the cucumbers were tender but firm and easily sliced.

The flavour was quite good in all cases. Series A, in vinegar only, were slightly preferable to Series B, and those with tighter packs being less acid were also preferred and had more cucumber flavour.

Summary.

Methods of bottling whole cucumbers in vinegar have been tested and an acceptable product with pH value 4.0 or under has been obtained by packing whole cucumbers with 5% vinegar diluted 1 part in 5 parts of brine, using sufficient acid brine to cover the cucumbers when originally packed, and boiling for 1½ hours.

THE KEEPING QUALITY OF CHUTNEYS.

By ALICE CRANG and MARGARET STURDY.

Introduction.

Recipes for chutneys vary considerably in their vinegar and fruit proportions, and during the last six years housewives have had to economise on both the sugar and vinegar used, with the result that some of the chutneys made have grown moulds and others have fermented. There are no definite commercial standards laid down for acid or solids content and so investigations were started to determine the minimum requirements.

Experimental.

The recipes used were those published by H.M.S.O. in "Preserves from the Garden," 1942 Edn. 3.

GREEN TOMATO CHUTNEY.

5 lb. Green Tomatoes.	1½ pints spiced Vinegar.
1 lb. Onions.	½ level teasp. Salt.
1 lb. Sugar.	¼ teasp. each ground Allspice, Cloves, Cinnamon, Mustard.

Another chutney was made using apples instead of tomatoes and 1½ lb. of sugar instead of 1 lb.

The spiced vinegar was made by using 5% vinegar with ¼ oz. each of whole cinnamon, mace, cloves, pimentoes and ¼ teasp. peppercorns, brought to the boil and then allowed to stand in a covered basin for at least 2 hours and strained before use.

Method for making Chutney.

Tomato Chutney. The tomato pulp was added to the sliced onion and cooked in a closed pan until soft. The flesh of the tomatoes was sliced and put in a weighed preserving pan with the sugar, spices, cooked onion and juice and the vinegar added slowly during cooking. The chutney was cooked to a given weight irrespective of consistency.

Apple Chutney. The onions were cooked in a little water in a closed pan, the apples minced and added to the cooked onion with the sugar and spices. The vinegar was added slowly during cooking and the chutney cooked to the desired weight.

The effects on keeping quality of the following modifications in quantities and procedure were tested for both apple and tomato chutneys :—

- (1) The yield of chutney was altered by varying the cooking time, giving different total solids contents.
- (2) The quantity of vinegar was varied, keeping the yield the same to give different acidity levels.
- (3) The quantity of vinegar and the yield were varied to give low acidity levels.

Storage Conditions.

Some jars were covered with metal caps lined with vinegar-proof paper, others of the same batches were covered with vinegar-proof paper, cardboard and parchment.

Some jars were inoculated with mould spores, immediately after filling the jars before covering with metal caps and also 24 hours after filling. The mould spores were previously taken from raw tomatoes and grown on nutrient plates.

The chutneys were stored for six months in a damp store, where some jams with mould on the surface were left alongside, to give severe storage conditions.

Determinations.

Each jar of chutney was mixed thoroughly before sampling.

Acidity was determined as acetic acid by titration with decinormal sodium hydroxide, using phenolphthalein as an external indicator. The weighed sample was ground in a mortar with a little sand and washed with distilled water into a conical flask. The volatile acidity was also determined in some cases by steam distillation.

Total solids were determined by drying the samples in a cool oven until constant weight.

The results are given in Table I.

Four other samples of green tomato chutney from outside sources which had grown mould on storage, had the following acidity and total solids contents :

E. (1)	Acidity as acetic acid	0.91%	Total Solids	30.4%
(2)	" " " "	0.86%	" "	23.5%
(3)	" " " "	0.69%	" "	22.4%
(4)	" " " "	0.99%	" "	28.0%

No mould grew, even in the inoculated samples, when the acidity of the chutney was above 1%. Below this level, there is a possibility of mould growth if contamination takes place before covering. As cooking apples are more acid than tomatoes, the acid level in apple chutney is not likely to fall below 1%, but in green tomato chutney, if the quantity of vinegar is reduced considerably from the recipe (sample 1), or if poor quality vinegar were used, the chutney might not store well.

A high total solids content of the chutney seems to be a contributory factor in the keeping quality when the acid content is border line (B 4), but mould grew on samples with high total solids content if the acid was low (E 1 and E 4).

Either of the methods of sealing the chutney was sufficient to keep the product free from mould provided that the chutney was covered at once.

Conclusion.

In these experiments, mould developed only on chutneys which had an acidity below 1% and had been inoculated with mould spores. None of the uninoculated jars grew moulds, showing that even with a low acidity, chutneys sealed at once in clean jars with vinegar-proof paper will withstand poor storage conditions; but the practice of leaving chutney in the jars open to the air for twenty-four hours before sealing is to be deprecated.

Results.

TABLE I.

Sample No.	Cover and Treatment	Vinegar	Yield	Acidity : % acetic acid	Volatile acidity % acetic acid	Total Solids %	Condition after storage
<i>Green Tomato Chutney</i>							
A 1	Metal	1½ pt.	5 lb.	1.71	1.09	30.6	No mould
2	"	"	6 lb.	1.56	0.90	22.3	"
3	"	"	7 lb.	1.50	0.89	22.3	"
B 4	"	½ pt.	6 lb.	} 0.88	0.7	26.6	{ "
"	Parchment	"	"				
5	Metal	¾ pt.	"	} 0.98	0.7	26.0	{ "
"	Parchment	"	"				
6	Metal	1 pt.	"	} 1.14	0.8	25.2	{ "
"	Parchment	"	"				
7	Metal	1¼ pt.	"	} 1.32	0.7	25.0	{ "
"	Parchment	"	"				
C 8	Metal	½ pt.	"	} 0.97		27.0	{ "
"	Inoculated	"	"				
"	Inoculated after 24 hrs.	"	"				
9	Metal	"	6½ lb.	} 0.84		25	{ No mould
"	Inoculated	"	"				
"	Inoculated after 24 hrs.	"	"				
10	Metal	¾ pt.	"	} 1.02		26.3	{ No mould
"	Inoculated	"	"				
"	Inoculated after 24 hrs.	"	"				
<i>Apple Chutney</i>							
D 11	Metal	1½ pt.	5½ lb.	1.4		41.6	"
12	"	"	6¼ lb.	1.4		38.2	"
13	"	"	6¾ lb.	1.61		34.3	"
14	"	½ pt.	6 lb.	} 1.02		37.0	{ "
"	Inoculated	"	"				
"	Inoculated after 24 hrs.	"	"				

A COMPARISON OF FIVE METHODS OF MAKING TOMATO JUICE.

By ALICE CRANG and MARGARET STURDY.

Introduction.

Various methods have been published in this country and in American Journals for home-made tomato juice and purée. The following tests were carried out to compare the merits of the different methods, having regard to palatability and ascorbic acid content.

Experimental.

The fresh, ripe tomatoes in late September were tested for ascorbic acid content (Vitamin C) by titration with 2-6 dichlorophenol indophenol dye in the usual manner. Five methods of making the juice were tested and the quantity obtained was weighed and measured. The juices were stored in glass preserving jars in a dark warm kitchen cupboard for six months before they were opened and tested for palatability, and ascorbic acid content by Mapson's method (1) using differential titration with formaldehyde, which showed that interfering reducing substances were absent.

Methods of Making Tomato Juice.

Aluminium pans with well fitting lids, stainless steel knives and hair sieves were used. The heating was carried out on a gas stove. The methods used are summarised in Table I.

TABLE I.
METHOD OF PREPARATION.

Methods	Quantity	Extraction	Reheating	Processing	Yield
1	6 lb. Tomatoes $\frac{1}{2}$ oz. Salt $\frac{1}{4}$ oz. Sugar $\frac{1}{2}$ pt. Water	Cook in closed pan 25 mins., sieve through hair sieve	Return to pan and bring to the boil	Pour into hot jars and heat in pan of boiling water for 10 mins.	5 lb.
2	do.	Cook in closed pan 25 mins., strain through scalded jelly bag	do.	do.	3 $\frac{1}{4}$ lb.
3	6 lb. Tomatoes	Cut fruit in slices, simmer 30 mins., sieve through hair sieve	Return to pan and bring to boil	Pour into hot jars and heat in pan of boiling water for 5 mins.	4 lb.
4	do.	do.	do.	Pour into hot jars and heat in pan of simmering water for 30 mins.	4 lb.
5	do.	Bake fruit in oven, sieve through hair sieve	do.	do.	3 lb. 10 oz.

In method 5 the fruit was placed on a tinned baking sheet in an oven at Regulo 3 and cooked until the tomatoes were just softened.

Results after Six Months' Storage.

All methods kept well and the juices were tested undiluted.

Flavour. Sample 1 was considered superior by everyone. Sample 2 was weak in flavour and the other three quite acceptable.

Colour. Sample 2 gave a clear yellow juice, samples 4 and 5 rather a deeper colour than 1 and 3, but all four were pleasant tomato colour.

Consistency. Sample 1 showed some separation of clear liquid at the tops of the jars, sample 2 had a small quantity of sediment at the bottom of the clear juice. Samples 3, 4 and 5 showed no separation.

TABLE II.
ASCORBIC ACID CONTENT.

Ascorbic Acid content mg/100g.				
Sample	Fresh Fruit	Stored Juice	Yield	% Retained
1	25.5	16.8	5 lb.	55
2	„	16.7	3½ lb.	35
3	„	17.7	4 lb.	46
4	„	18.5	4 lb.	48
5	„	20	3 lb. 10 oz.	47

The figures for ascorbic acid retained are obtained by expressing the quantity in the stored juice times the yield as a percentage of the original ascorbic acid in the 6 lb. of tomatoes used.

Discussion.

All methods gave acceptable products without any very great difference in the final ascorbic acid content for equal quantities of juice. The shortest time for processing, five minutes in boiling water, was satisfactory for keeping quality, and did not alter the ascorbic acid content markedly. In sample 1 the added sugar and salt and the rather thinner consistency gave a more palatable product than the other samples, and this would seem to outweigh the fact that there was rather less ascorbic acid than in sample 5.

The clear juice in sample 2 was not so attractive or palatable, and the ascorbic acid content was the lowest of the five tested. This product is wasteful of fruit, giving the lowest yield, so that on all counts the method is not as good as the others.

Summary.

Five methods of making tomato juice were compared for palatability and ascorbic acid content.

The method published by the Ministry of Agriculture in Bulletin No. 21 gave the best retention of ascorbic acid, the highest yield of juice and the most palatable product.

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FACTORS AFFECTING QUALITY IN POTATOES. III.

By A. POLLARD, MARGARET E. KIESER and ALICE CRANG.

The present tests are a continuation of those made in 1944 and 1945 which have been described in the Reports for those years (1, 2). A more general account of the tests has also been published elsewhere (3). In the 1946 season the cooking quality of samples from six centres was examined, three of the centres being among those included in the previous trials. Samples from sand culture experiments were also tested.

The influence of site and variety on potato quality was again evident in 1946, but the improvements brought about by manurial treatment have been more striking at some centres, for where the initial level of quality, although still poor, has been better than in previous years, it has been possible to produce relatively good potatoes by the use of fertilisers.

Blackening has again been associated in the field with potash deficiency and has been reduced by potash dressings. In sand culture there has been some relation between blackening and iron and phosphorus levels.

Of the few varieties tested, Majestic has again shown the greatest liability to blacken under unfavourable conditions.

Methods.

The methods used for carrying out the tests were those described previously, tubers of average specific gravity being selected from the samples as received. Scores for colour, external appearance, flesh consistency and flavour were awarded as before, ranging from 0 to a maximum of 5.

(a) Field Observations.

Centre I. (Long Ashton. Plot 12). This was adjacent to the plot used in 1945 and it had been used for comparisons of organic and inorganic fertiliser treatments on crop rotations. The field results showed that the only deficiencies apparent were those of N and Mg where compost or dung alone had been given. The symptoms were relieved where nitrogen was applied in addition.

Centre II. (Swaffham). This trial was in the same area as Centre II in 1945 (2) and Centre A in 1944 (1). It was on a light Black Fen peat. A basal dressing of sulphate of ammonia was given at the rate of 2 cwt. per acre and sixteen combinations of phosphate and potash were applied in triplicate. Superphosphate was applied at the rates of 0, 5, 10 and 15 cwt. per acre and muriate of potash at the rates of 0, 2, 4 and 6 cwt. per acre. In July symptoms of phosphate deficiency were seen on plots which had received no phosphate and symptoms of potash deficiency were seen on plots which had received no potash, but the effects were confined to a few plants in each case. The addition of P was seen to give an improvement in vigour of growth, whereas the addition of K had no such effect.

Centre III. The soil at this centre in the Leicester area was derived from Bunter sandstone and was very deficient in organic matter. Attempts to build up an organic reserve had been made by straw composting and by the use of sewage sludge. The poor quality of potatoes grown on this site had suggested a deficiency of some nutrient although visual symptoms of K deficiency had not been general and soil analysis had indicated an apparently

high P level. The manurial treatments given consisted of different levels of a balanced fertiliser with supplements of superphosphate and muriate of potash to test the response to additional supplies of P and K.

Centre I V. This site in the same area as Centre III was on stiff boulder clay up to eighteen inches in depth and overlying gravel. It was in the grounds of a Municipal Sewage Works and had received floodings of sewage sludge at intervals during the past 50 years. The levels of P and K appeared high from soil analyses, but potato yields had not been high for some years, the top growth had been rank and symptoms suggesting K deficiency complicated by toxicity conditions had usually followed. In the 1946 season potatoes on the site were given N, P and K dressings in several combinations at the levels, sulphate of ammonia 0, $1\frac{1}{2}$ and 3 cwts./acre, superphosphate 0 and 4 cwts./acre and muriate of potash 0, 2 and 4 cwts./acre.

Centre V. Details of this centre on broken up acid heath land were given in the Reports for 1944 (Centre C, p. 191) and for 1945 (Centre V, p. 210). The visual symptoms in the 1946 growing season were mainly those observed in 1945, but with some modifications. In the plots receiving no lime, the symptoms were those of "acidity" rather than of calcium deficiency alone, *i.e.* they were the result of low pH and manganese toxicity. Where lime was applied, symptoms of —N, —P and —K appeared where these elements were not given. Mg deficiency was more prevalent in the PK treatment than in the NPK treatment and was associated with low N. The gradients of P and K across the plots which were evident in 1945 were not marked in 1946 and the duplicate no-manure plots produced more similar tubers in the later season.

Centre VI. This plot was also described in previous reports (Centre D in 1944, Centre VI in 1945) and comprised experimental fertiliser plots and acidity plots showing a pH range of 4 to 6. As formerly, soils of low pH produced acidity effects during the growing season. Symptoms of K deficiency were again severe where this element was not given, but the —N symptoms were less severe in 1946. As before, the supply of P appeared adequate.

Long Ashton. Pot. Experiments (P K Fe series). This experiment was virtually the same as that of 1945, sand cultures being given three levels of phosphate, potash and iron. In 1945 either potash and iron appeared capable of reducing deficiency of the other element; in 1946 this was confirmed in so far as symptoms of iron deficiency were reduced by giving potash. On the other hand, although —K symptoms appeared earlier with low iron, they were eventually most severe at the high iron level.

(Ca, Mn series). In this series calcium and manganese were given to sand cultures at two pH ranges, viz. 3.0 and 5.5. The levels were as follows :—

Ca	Mn
0 (waxed pots).	low (normal).
low (pot Ca).	high (150 p.p.m.)
high (250 p.p.m.)	

Symptoms of acidity conditions were produced by excess manganese and low calcium and the effects of manganese toxicity were reduced by the presence of soluble calcium.

(b) Cooking Tests.

Centre I. Long Ashton.

Majestic. The samples were excessively wet and broken after boiling, but the flavour was good and blackening was slight, the lowest individual

colour score being $3\frac{1}{2}$. Blackening was most noticeable in the samples from plots receiving the higher application of N (organic), but the effect was not marked. Texture was poorest following the use of dung or compost alone, the samples being very broken.

King Edward. The samples resembled Majestic in texture and appearance. They were rather better in flavour, and blackening was virtually absent. The samples were again very wet and broken, but the effects of manurial treatment were not striking.

Kerr's Pink. Although this variety was also too broken on boiling, the tubers were more solid and starchy than either Majestic or King Edward. Blackening was absent. The majority of the tubers had, however, a peculiar appearance after boiling, the outer surfaces were gummy and translucent, and the effect was not confined to any manurial treatment.

Centre II.

Majestic. Apart from their colour, the samples were of moderately good quality. Texture was variable, some samples being broken while others were too close and solid, although they were not sticky in texture. Blackening was general and varied in intensity from slight to severe, individual scores for colour ranging from $1\frac{1}{2}$ to $4\frac{1}{2}$. The average scores for the P and K levels are given in Table I, from which it appears that blackening was most severe where K was not given and it decreased with increasing amounts of K. On the other hand, external appearance and consistency appeared best where K was not applied, but they showed improvement following the use of phosphate. A statistical analysis of the original data by Mr. F. Hanley confirms these general conclusions and shows furthermore that the beneficial effect of potash on colour and the adverse effect on appearance are significant, but that the differences between the K treatments are not significant. Similarly, the beneficial effect of phosphate on appearance, consistency and flavour are significant, but no additional improvement is given by an increase over the first (P_5) dressing. The analysis also showed that consistency was best where phosphate and potash were given together rather than separately.

TABLE I.
AVERAGE SCORES FOR P & K LEVELS.

	K_0	K_2	K_4	K_6	P_0	P_5	P_{10}	P_{15}
Colour	2.6	3.2	3.6	3.7	3.3	3.3	3.0	3.4
External Appearance	3.6	3.4	3.1	2.8	2.7	3.6	3.3	3.3
Consistency	3.9	3.4	3.5	3.4	3.2	3.7	3.7	3.6
Flavour	3.7	3.5	3.5	3.5	3.0	3.6	3.7	3.8

Centre III.

Gladstone. The samples were of moderate quality but were not sufficiently floury. Blackening was present but was not severe, the lowest colour scores being 3. The considerable variations in quality found between duplicate plots receiving the same treatment made it impossible to draw very definite conclusions. Blackening was practically absent in plots receiving balanced fertiliser with additional muriate of potash, but where extra potash and extra

phosphate were both applied there was no improvement above the general level. Muriate had some adverse effect on texture and gave tubers with more shiny appearance. Apart from the colour, the best all-round quality was shown by the samples receiving balanced fertiliser at the lowest rate.

Centre I V.

King Edward. Although the samples were of poor quality with shiny surfaces and sticky texture, blackening was only definite in one sample and it did not appear related to the fertiliser treatment. The poor texture of the samples was not improved by any of the NPK treatments and the use of muriate of potash alone gave the worst sample in this respect. The flavour of the samples was slightly better where phosphate was given.

Centre V (Sutton Park).

Majestic. The samples were of poor quality, texture was solid, flavour poor and blackening severe. Individual scores for colour ranged from 1 to $4\frac{1}{2}$, the majority being between 2 and 3. Where lime was not given the tubers were small, solid and of poor flavour. As shown in Table II those receiving 3 tons/acre were slightly better, while those receiving 9 tons/acre showed some flouriness on boiling. The colour of the samples was, in general, worse after liming.

Where no lime was applied, fertiliser treatments had little effect on appearance, consistency or flavour, but there was some effect on blackening. Potash had a beneficial effect, for blackening was most severe in the nil and NP plots (Table III). Where lime was given, blackening was more variable and plots not receiving K showed yet increased blackening especially at the higher rate of liming, where the average colour score for plots not receiving K was 1.8 as against 3.4 for those receiving K.

TABLE II.
CENTRE V. AVERAGE SCORES AT DIFFERENT LIME LEVELS.

			External Appearance	Consistency	Flavour	Colour
No lime	..	..	2.5	2.2	1.6	3.4
3 tons/acre	..	..	2.2	2.8	2.8	2.5
9 tons/acre	..	..	2.9	3.2	2.4	2.6

TABLE III.
CENTRE V. COLOUR SCORES FOR TREATMENTS.

Lime tons/acre	Control	P	NP	K	NK	PK	NPK	Control
0	$2\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	4	4	$2\frac{1}{2}$
3	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$1\frac{1}{2}$	2
9	2	2	1	$3\frac{1}{2}$	$2\frac{1}{2}$	$3\frac{1}{2}$	4	2

Centre VI (Harper Adams).

Majestic (pH plots). The samples from the most acid soils (pH 4.5 to 5.4) were small, solid and immature in appearance and had an unpleasant flavour. Blackening was variable and showed no apparent relation to soil pH.

(Fertiliser plots): The samples showed much variation and those from plots not receiving K were very close in texture and of poor appearance; the flavour was also inferior (Table IV). Blackening was present in some samples but was not severe. It was absent in the control plot and was absent or slight in the K, PK and NK plots; the lowest colour scores (3) were given by the N and NPK plots. Blackening thus appeared to be increased by N but to a variable degree.

TABLE IV.
CENTRE VI. AVERAGE SCORES FOR FERTILISER TREATMENTS.

Treatment	External Appearance	Consistency	Flavour	Colour
Nil	2.0	3.0	3.0	5.0
NP	1.0	2.2	2.5	4.0
K	4.0	4.5	4.5	5.0
NK	3.7	4.5	4.5	4.7
P	3.0	3.0	4.5	4.5
PK	3.7	4.2	4.2	5.0
N	2.0	3.0	3.5	3.0
NPK	4.5	4.0	4.5	3.0

Long Ashton Pot Experiments.

Majestic (Fe K P treatments): The tubers from pots not receiving K or P were very small and immature in appearance. At the higher K and P levels they showed more breakage on boiling but still lacked flouriness. As shown in Table V, slight but definite blackening was seen in the treatments

TABLE V.

	K_0P_1	K_1P_0	K_1P_1	K_1P_2	K_2P_1
Fe_0	—	+	—	—	—
Fe_1	—	+	—	—	—
Fe_2	—	+	+	—	—

+ signifies definite blackening.

$Fe_0 K_1 P_0$, $Fe_1 K_1 P_0$, $Fe_2 K_1 P_0$ and $Fe_2 K_1 P_1$; i.e. at all Fe levels where P was low and also where Fe was high and P intermediate. In this test blackening thus appears related to low P rather than to low K, for the treatments $K_0 P_1$ did not show definite blackening. At the higher Fe level, blackening was found in some P_0 and P_1 treatments.

(Ca Mn treatments): Where Ca was not given the tubers were small and

immature in appearance; where Ca was given they were more normal in appearance and were floury. Real blackening was only seen in one sample (high Ca, normal Mn) and was not severe. Some of the tubers from pots not receiving Ca had a transparent appearance due to lack of starch but the effect was not invariably seen nor were all tubers in the particular samples affected.

General Discussion.

Comparison of results with those of previous years.

Long Ashton. A strict comparison between the 1946 samples and those of previous years is not possible, for cooking samples had not been taken from this plot before. They resembled the 1945 crop in being very wet and over-mealy, the condition again being worst where dung or compost alone had been applied. Blackening was slight in 1946 and less than that found in the adjacent plots in the two earlier seasons.

Long Ashton Pot Experiments. The first true blackening in these trials was found in the 1946 season in the Fe, K, P series. In 1945 this experiment had produced no definite effect on colour. In both seasons low K gave small tubers of immature appearance, but in 1946 the tubers from the low P treatments were also of this type. The chief difference between the samples in the two years, apart from the blackening in 1946, lay in the absence of the intense yellow colour which was so noticeable in the 1945 crop.

Centre II (Swaffham). The 1946 samples were much better in quality than those received from this area in previous seasons; they were better in texture and flavour and although blackening was still considerable, it was less severe than before. As in the earlier tests, potash fertilisers gave an improvement in colour, and since the general level of blackening was less in 1946, the effect of potash was more striking. Phosphate had a marked effect on texture and appearance in 1946, whereas in previous tests little benefit had been seen. Fertiliser treatments in this season were thus able to produce a considerable improvement in quality as the basic level of the crop was better.

Centre V. (Sutton Park). The potatoes from this trial were again poor in texture and, as in previous years, showed extensive blackening. Yield and texture were again improved by liming, but blackening was intensified. In contrast to the results of the 1944 and 1945 trials, fertiliser treatment in 1946 produced some effect even without liming. In the earlier trials the beneficial effect of potash on colour had only been shown after the calcium deficiency had been corrected, but in 1946 an improvement was also found before liming.

Centre VI. (Harper Adams). Majestic grown on these plots in 1946 showed less blackening than in 1945, but as before it was intensified by the addition of N and decreased by the addition of K. Texture was again adversely affected by withholding K, the samples being very close and solid.

The samples from the acidity plots showed more response to soil pH than in previous years, for in the present tests the more acid soils gave tubers of solid and immature appearance. Blackening was much the same in 1946 as in 1945, and again showed no relation to soil pH.

Varieties and Sites.

Samples of Majestic were grown on four sites, King Edward on two sites, and Kerr's Pink and Gladstone each on one site. As before, Majestic when grown at Long Ashton was of fairly good quality and showed little blackening. On the other sites quality was poorer and blackening more serious, especially

at Centre V (Sutton Park). On the fenland site Majestic was of better colour than in previous years. King Edward at Long Ashton was very similar to Majestic in general quality but showed less liability to blacken. At Centre IV this variety was of poor quality, the tubers being heavy and sticky. Blackening was, however, practically absent although tubers of this type of consistency have frequently been found to blacken seriously. Gladstone from this area was also rather heavy in texture and showed some blackening. Kerr's Pink grown at Long Ashton suffered from excessive mealiness as did the other two varieties Majestic and King Edward, but the samples received higher quality ratings as they were more starchy and less watery; blackening was not seen in any sample of this variety.

In this season, as in the earlier trials, blackening has been determined by the site. The intensity of blackening has been less at some sites and more response has been shown to fertiliser treatment. This was especially the case at Centre II where symptoms of P and K deficiency were less severe in 1946. At this site the use of suitable fertilisers has been able to give a crop of reasonable quality for the first time.

Manurial Treatments.

The general conclusions drawn in 1944 and 1945 were found to hold in the 1946 trials, *i.e.* that the correction of definite mineral deficiencies gave an improvement in quality, the extent of the change being determined by other site factors. Symptoms of K deficiency were severe at Centres V and VI; at Centre II they were less severe than in the previous years. At Long Ashton the main deficiency was of N in the plots receiving dung or compost alone. At Centre III there was a lack of organic matter and crops had been poor, although mineral deficiencies had not been striking. At Centre IV apparently adequate levels of P and K in the soil had been accompanied by poor crops showing foliage effects suggesting a toxic condition with possibly potash deficiency. The effects of the fertiliser treatments at these sites may be summarised as follows.

The effect of potash on blackening was seen at Centres II, V and VI, where blackening was reduced by an increase in the K level. At Centre II the symptoms of K deficiency in 1946 were less acute than in the previous seasons and blackening was less severe; furthermore, the improvement produced by giving K was more striking. At Centre V, where potash deficiency was secondary and where the main deficiency was Ca coupled with acidity conditions, it was necessary to correct the latter before the yield and general quality could be improved. But even under these conditions, and before lime was applied, the beneficial effect of K on colour was demonstrated. Similarly after the correction of the Ca deficient conditions the effect of K was again seen. At Centre VI the incidence of blackening was again related to the K level.

The chief effect following the use of phosphate has been an improvement in the texture of the samples. This was especially evident at Centre II, where the correction of the deficiency conditions gave an improvement in texture and in the starch content of the tubers. A slight improvement in texture following the use of P was also seen at Centre III. In the sand cultures there was some relation between blackening and phosphate and iron level, but no definite conclusion could be drawn and further tests are required.

The level of nitrogen has been found associated with the texture of the samples and at Long Ashton the plots showing deficiency symptoms in the

foliage (coupled with Mg deficiency) have given very wet and broken tubers. At Long Ashton and at one other Centre (VI) nitrogen has tended to increase blackening, but this effect has not been noted in the other tests.

The poor response to fertiliser treatment at Centre III and IV suggests that the quality of the potatoes is dependent on other factors. At Centre III the lack of organic matter and the absence of severe deficiency symptoms suggest that humus content and possibly soil pH may require correction. At Centre IV the visual foliage symptoms and the history of the plot suggest toxicity conditions (*e.g.* Cr, Zn or Cu) as a main cause of poor quality. In such a case little improvement would be expected to follow the use of N, P, K fertilisers and liming would be indicated.

The use of muriate of potash as a source of potassium has been associated with an adverse effect on texture. Where the potatoes have been of a soapy texture, the condition has been aggravated and the tubers have been more shiny in their outer appearance and sticky in texture. This has been shown particularly in the trials at Centres II, III and IV. The effect was most noticeable at Centre II, where the results of the cooking tests were in close agreement with the specific gravity determinations on the samples. Tubers with shiny surfaces and poor consistency were found in the samples with low specific gravity, *i.e.* with lower starch content. The average values for the specific gravities at the different P and K levels are shown in Table VI, and it will be noted that while the application of phosphate gives an increase in density, potash as muriate produces a decrease. The increase following the use of phosphate is only significant for the first dressing (P_5), the differences following further addition being less than the amount required for significance (*viz.*, 0.0019 at the 5% level). The decrease in specific gravity following the use of muriate is significant at both K_2 and K_4 levels, further addition giving no significant decrease (significant difference 0.0019 as before).

TABLE VI.
AVERAGE VALUES FOR SPECIFIC GRAVITIES AT DIFFERENT P AND K LEVELS.

P_0	P_5	P_{10}	P_{15}
1.0730	1.0756	1.0752	1.0768
K_0	K_2	K_4	K_6
1.0808	1.0755	1.0730	1.0712

This effect of chloride has been noted by many workers, for example, Cowie (4) found that muriate of potash or more especially kainit depressed the dry matter content and also that blackening might be intensified by high concentrations of chloride. Dunn and Nylund (5) and Dunn and Rost (6) also found this effect of chloride on specific gravity and the latter authors pointed out that while this was deleterious on heavy soils, the effect might be an advantage on light soils. This conclusion has been borne out in the present series of trials, for as already pointed out (3) where tubers suffer from excessive breakage, as on some of the light soils at Long Ashton, a decrease in mealiness gives a potato of better cooking quality.

It is not possible to draw any conclusion from these tests as to any effect of chloride on blackening, for muriate of potash was the sole source of potash used, this being the only form generally available to the farmer. Although potash fertilisers containing high concentrations of chloride, *e.g.* kainit, have been found to promote blackening, the intensification of blackening by muriate of potash is less definitely established. In the Long Ashton plots in 1945 potatoes given potash as chloride were not inferior to those receiving the

sulphate, although symptoms of chloride toxicity were seen in the haulm. Only where sodium chloride replaced the potash salt was any appreciable increase in blackening observed and even there it was slight. The possible effect of muriate of potash in restricting the beneficial effect of K on other sites or other types of soil could only be determined by a comparison of the sulphate and muriate on the particular site.

Conclusions.

The results of the present tests are in agreement with those of the previous years, viz., that where poor quality in potatoes is related to definite deficiencies of particular nutrients, the correction of those deficiencies gives an improvement in quality. The extent of the improvement is dependent on other site factors and only where the basic level of quality is sufficiently high can manurial treatment produce a crop of good quality.

In the experimental plots blackening has been similar in intensity to that found in previous season. In field trials blackening has been rather less intense than in the two previous seasons. The general quality of the potatoes has been similar to that in 1945, and many samples have suffered from excessive breakage on boiling. Of the varieties tested, Majestic has shown the greatest liability to blacken under unfavourable conditions but has been little inferior in other respects.

Summary.

1. A further study has been made of the factors affecting the cooking quality of potatoes, paying particular attention to the incidence of blackening on boiling.

2. Six centres were included in the tests, of which three had been used in the two previous seasons. Deficiencies of N, P, K, Ca and Mg were encountered and the effects of manurial treatments were noted. Most of the tests were carried out on the variety Majestic, but samples of three other varieties were included in the trials.

3. As found in previous years, the quality of the potatoes was governed mainly by the character of the site, the response to fertiliser treatment varying accordingly. The improvement following the use of fertilisers was more noticeable at some sites in 1946 as the general level of quality in the untreated plots was better than before.

4. The correction of deficiencies produced an improvement in potato quality and the correction of K deficiency gave an improvement in the colour of the cooked samples. Where poor quality was not directly due to mineral deficiency conditions, the use of fertilisers gave little improvement in quality.

5. The use of muriate of potash as a source of K lowered the dry matter content of the tubers, producing poorer appearance and texture on some sites.

6. The use of N where K was low gave some increase in blackening, but the effect was not general. Lack of N was associated with excessive breakage of the cooked potatoes. Phosphate had no apparent effect on blackening in the field, but in sand culture slight blackening was seen where the level of phosphate was low. In the field trials phosphate had a beneficial effect on the texture of the samples, and this was greatest where the level of K was adequate.

7. On a site where Majestic blackened slightly, the varieties Kerr's Pink and King Edward were free from blackening. King Edward on another site showed little blackening although the general quality was poor. In this area Gladstone blackened to a greater extent.

Acknowledgments.

We wish to thank the following for co-operating in the field tests and supplying samples of tubers for cooking :—

Mr. W. Morley Davies, Harper Adams Agricultural College,

Mr. F. Hanley, School of Agriculture, Cambridge, and

Mr. H. T. Cranfield, Midland Agricultural College, Sutton Bonington.

Thanks are also due to Miss M. Sturdy for assistance in the cooking tests and to Miss J. D. Bryan and Miss M. Moseley for their help in preparing the samples.

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BRISTOL UNIVERSITY AGRICULTURAL ADVISORY CENTRE 1912–1946.

By R. W. MARSH.

With the setting up of the National Agricultural Advisory Service in October 1946 the Bristol University Agricultural Advisory Centre ceased to exist. Despite its short life, which included two major wars, the Advisory Centre played no inconsiderable part in the development of agriculture and horticulture in the Bristol Province. The connection between the advisory work of this Province and the Research Station has always been a close one, and it therefore seems appropriate that some record of the salient points in the history of the Centre should appear in this Annual Report.

1903—12. Advisory work of the Cider Institute prior to its association with Bristol University.

In 1903, when the National Fruit and Cider Institute was founded at Long Ashton, it was recognised that among its functions would be the provision of technical advice to farmers, cidermakers and fruit growers. To quote the words of the Articles of Association, one of the objects of the Institute was “to disseminate, as from time to time may be deemed desirable, by means of classes, lectures or any such methods, such results of investigation and research as may be considered likely to be of use” (6).

Until 1911, the Director, with the sole assistance of Mr. John Ettle, added to his research activities the organization of demonstrations and educational exhibits, the publication of advisory leaflets, and the maintenance of courses in fruit culture and cidermaking in conjunction with University College, Bristol. These courses were suspended on the establishment of Bristol University in 1909, but this local organization of an advisory service is noteworthy as a precursor of the national scheme described below.

1912—24. The First National Advisory Scheme.

Following the setting up of the Development Commission in 1909, the year 1912 saw the beginning of the first scheme for an agricultural research

and advisory service to cover the whole of England. The research work was allotted to institutions which were, when possible, to be connected with a university (2); and the advisory service was centred on universities or agricultural colleges (3). As a consequence of this scheme, the Long Ashton Institute became associated with the University of Bristol in 1912 to form the Department of Agricultural and Horticultural Research, while the University also became the headquarters of an advisory province made up of the counties of Gloucester, Hereford, Somerset, Wiltshire and Worcester. The advisory work for this province was undertaken by the Department on behalf of the University.

Long Ashton thus became both a research and an advisory centre under the national scheme, although advisory appointments to the staff were not specifically distinguished from research posts until 1922. However, one of the aims of the appointments in 1912 of Mr. C. T. Gimingham as soil chemist and of Mr. A. H. Lees as plant pathologist was the strengthening of the advisory work of the Station.

From 1913 onwards, co-operation with others concerned with advisory work in the province was maintained through a Provincial Advisory Conference. This conference included representatives of county staffs, Ministry of Agriculture inspectors, the Long Ashton staff and members of staff of other University departments. Meetings were normally held quarterly and occasionally joint sessions were arranged with the provincial conferences of adjoining areas. The Advisory Centre constantly maintained close relations with the allied pure science departments in the University.

The first report on Advisory Work appeared in the Long Ashton Annual Report for 1913, and the series has been maintained down to the present issue. In 1914 the total of advisory letters recorded was 130. Mr. Gimingham was seconded from 1916 to 1918 for work on chemical warfare, but the advisory work was continued during the 1914-18 war mainly by Mr. Lees and Mr. Spinks, who, in 1917-18 were also much occupied with the potato spraying campaign.

Reorganization in 1919-24. In January 1919 Mr. Gimingham returned to Long Ashton and took charge of advisory work in chemistry, Dr. Wallace being appointed as his assistant for research work. Mr. Lees remained responsible for advisory work in entomology and Professor Barker and Mr. Grove dealt with cider enquiries. Dr. S. P. Wiltshire was appointed for research in mycology but also undertook advisory duties in this subject. Later in 1919 Mr. Gimingham resigned and Dr. Wallace was appointed Adviser in Agricultural Chemistry, taking up such local problems as lead poisoning of stock, lime-induced chlorosis, leaf scorch of fruit trees and improvement of rough pastures by the eradication of bracken and manurial treatments. The last-named investigation was promoted by the Experiments and Education Committee of the Bath and West Society, the parent body of the National Fruit and Cider Institute.

By 1922 the total number of advisory enquiries had risen to 478, and an entomologist (Mr. E. Ballard) was appointed specifically for advisory work, Mr. Lees becoming the Research Entomologist. In the following year the Ministry of Agriculture set up a committee, with Prof. Barker as chairman and Dr. Wallace as secretary, to deal with Fruit Soil Surveys. A survey of the Old Red Sandstone area of the West Midlands was recommended and Dr. Wallace was given a research assistant (Mr. A. W. Ling) to assist in the soil analyses required in this investigation.

The University, in 1923, took the initiative in appointing its own Agricultural Information Officer to deal with enquiries from the contributing counties. This post was given to Dr. J. A. Hanley, then Advisory Chemist at Leeds University.

1924—30. The Development of Advisory Work at Berkeley Square and at Long Ashton.

In 1921, when the Corn Production Act was repealed, a new development fund for agricultural research and technical advice was initiated. By 1923 it had been decided that among the beneficiaries of the new fund should be the specialist advisory service. It therefore became possible in the succeeding years to increase materially the size and scope of the advisory service in the Bristol Province.

Staff.

In 1924 the University set up, under Dr. Hanley's administration, an Agricultural Advisory Office at 22, Berkeley Square, Bristol, with advisers in Agricultural Chemistry (A. W. Ling), Agricultural Economics (E. P. Weller 1924-28, then Dr. C. V. Dawe), and Dairy Bacteriology (H. R. Jones 1924-27; C. A. MacEacharn 1927-30). In 1927 Dr. Hanley became, in addition, Principal of the Royal Agricultural College at Cirencester and Mr. Ling was made administrative officer at Berkeley Square. At Long Ashton, L. N. Staniland succeeded Mr. Ballard in 1924 as advisor in Economic Entomology and R. M. Nattrass (followed by L. Ogilvie in 1928) and H. P. Hutchinson were appointed to the newly-created advisory posts in Economic Mycology and Willow-growing respectively. Long Ashton also retained responsibility for the advisory work in cider and fruit products, horticultural chemistry and pomology. In 1925 Dr. D. A. Osmond was added to the Long Ashton staff as Soil Survey Officer and in the next year P. T. H. Pickford was appointed instructor in cider-making under a special scheme financed by the counties of Dorset, Monmouth and Worcester.

Subjects.

The main trends of development of the advisory work in 1924 and the succeeding years were naturally governed by the situation of the farming industry at that time. The repeal of the Corn Production Act had led to a widespread reduction in cereal acreage. In the West of England, particularly, laying down of land to grass was the general rule and farming became more and more concerned with milk production, although the provision of a subsidy for sugar beet encouraged the growing of this crop. Poultry keeping increased and developed, and specialization in fruit and vegetable growing became more pronounced. Prices for all farm commodities were low, and consequently the subject of costings assumed outstanding importance.

With the opening of the Agricultural Advisory Office, immediate attention was given to the improvement of pastures, and the method worked out under the auspices of the Bath and West Society for eradication of bracken from hill grazings was widely demonstrated in 1926-30. Concurrently the improvement of acid pastures was investigated and this led in turn to studies of the utilization of a range of liming materials. The benefits of manuring for the correction of acidity were also demonstrated on arable land, and a programme of sugar beet research was inaugurated.

The importance of milk production in the Province was reflected in the rapid and continuous expansion of the work of the Adviser in Dairy Bacteriology. The general aim of this work was the up-grading of farm supplies of milk by reduction of their bacterial content. This necessitated the examination of many thousands of samples yearly, at first for the entrants for the voluntary Clean Milk Competitions and, subsequent to 1926, in fulfilment of the requirements of the Milk and Dairies Order.

Milk production was also studied by the Adviser in Agricultural Economics who established, year by year, the average cost per gallon of production in the Province. Similar costings were carried out on wheat and sugar beet and analyses of a selection of farm accounts were made. These studies were of the greatest value in arriving at price fixing agreements between producers and buyers. By lectures and demonstrations farmers throughout the Province were instructed in accurate methods of accounting.

The advisory activities of the Long Ashton Station were concerned mainly (though not exclusively) with the specialist growers of fruit, vegetables, hops and willows and with the problems related to cider production. In advisory chemistry, as an extension of research findings, special attention was directed to the manurial requirements of fruit. Field experiments, carried out in collaboration with the county horticultural officers, demonstrated the outstanding effects of potash in overcoming leaf scorch. This discovery brought back into productivity large areas of semi-derelict plantations in the West Midlands. A survey of the Old Red Sandstone soils in this area was made in 1922-26 and of the Lower Lias in the Evesham region in 1926-31.

In entomology, the benefits of winter spraying with tar oils were shown by trials in the principal fruit growing areas during 1925-29. During this period capsid bugs became a new pest of fruit and methods for their control were devised. Other fruit problems dealt with by the adviser were the pests and disorders of strawberries and the control of the loganberry beetle. In 1929 a programme of experiments carried out jointly by Mr. R. C. Gaut (County Organiser for Worcester) and Dr. Walton (then Research Entomologist at Long Ashton) publicised the method of using a derris suspension to prevent warble fly attack on cattle.

The advisory mycologist, in field trials near Cheltenham in 1924-26, showed how American gooseberry mildew could be effectively controlled by sulphur dusting; he also studied the fungus diseases affecting the willow crop in Somerset. With the appointment of Mr. Ogilvie in 1928 work was begun on the fungus and virus diseases of market garden crops, particularly in the Evesham area. The importance of these studies necessitated the appointment in 1930 of an assistant for vegetable disease investigations. Work was also started on glasshouse crops and on the diseases occurring in the Worcestershire and Herefordshire hopyards.

The history of the cider advisory work at Long Ashton dates back to the foundation of the Cider Institute. Annual cider competitions and the establishment of trial orchards in the contributing counties were started in the early years of the Station's existence, and by 1924 much information was available concerning the growth, fruiting and vintage qualities of a wide range of cider varieties. The improvements in cider-making arising from the work of the Station were being fully utilised by the makers of cider on a factory scale, but the standard of cider-making on farms remained generally low. A scheme for the provision of local instruction in cider-making was launched in 1926, and in the following year 231 visits were made to farm cider-makers.

The results of these advisory visits rapidly became apparent in the improvement in quality of farm-produced ciders.

The adviser in willow-growing had no parallel elsewhere, and, in consequence, his assistance was called upon, not only by the Somerset willow-growers, but also by those throughout the British Commonwealth. He planted and maintained at Long Ashton a unique collection of all types of willows and gave particular attention to the problems of cricket bat willow cultivation.

Number of Enquiries.

The growth of the advisory service was reflected in the number of recorded enquiries, which rose to 1,094 in 1925 and 2,282 in 1930. These figures, however, give a very incomplete picture since they take no account of visits, telephone calls or the routine letters in the Economics and Dairy Bacteriological department. Supplementing the replies to individual enquirers were articles and leaflets, lectures and show exhibits, while the first of a long series of broadcast talks was given in 1925.

1930—39. Further Extensions of the Advisory Services.

Staff.

In 1930, on his appointment to the Chair of Agriculture at Newcastle, Professor Hanley resigned the appointment of Chief Advisory Officer. In the same year, Mr. C. S. Miles succeeded C. A. MacEacharn as Adviser in Dairy Bacteriology. In the following year two important advisory subjects were added to the work of the centre; Mr. W. D. Menzies became its first Veterinary Advisory Officer and Miss M. L. Adams transferred to Long Ashton the advisory work in domestic preservation of fruit and vegetables (1). This latter work had hitherto been carried on at the Campden Research Station, but from 1931 the Campden Station became concerned exclusively with research and advisory work on commercial canning. Miss Adams' courses of instruction in fruit preservation were from 1931 to 1939 accommodated at the Royal Agricultural College, Cirencester. Miss Adams was succeeded first by Miss Ferguson in 1935, then by Miss Crang in 1938.

In 1931 Dr. H. G. H. Kearns was appointed Advisory Entomologist but transferred the following year to the Research Staff, Dr. C. L. Walton becoming the Adviser. However, by special arrangement, the advisory work on fruit pests remained under the charge of Dr. Kearns.

The increasing importance of poultry diseases necessitated the appointment of a poultry pathologist, J. S. Garside, under the Veterinary Officer in the same year. This appointment was not officially one in the advisory service as the post was self-supporting: in practice, however, the poultry pathologist worked in close collaboration with his colleagues at the Berkeley Square Centre. Miss E. H. L. Duncan succeeded Mr. Garside in 1938.

The assistant in vegetable diseases, working under the Advisory Mycologist was B. O. Mulligan until 1934, next P. W. Brian, followed by C. J. Hickman (1934-38), then H. E. Croxall.

In 1933, J. W. Egdell became Adviser in Dairy Bacteriology, succeeding C. S. Miles. The Willow Advisory Officer, Mr. H. P. Hutchinson, retired in 1939.

Subjects.

A very brief review of the state of agriculture in 1930-39 would show that it remained, on the whole, a depressed industry almost up to the outbreak of

the 1939-45 war. However, the setting up of the Milk Marketing Board stabilised the prices of dairy products, and the systems of designated milk grades put a premium on clean milk production. The fruit growing industry suffered from alternate frost years and gluts; when crops were plentiful there was a demand for new outlets for the disposing of surpluses. The National Mark marketing schemes, although adopted by relatively few growers, had an educational value in demonstrating the steady market prices of clean fruit, properly graded and packed. This led to increased interest in pest and disease control.

The poultry industry reached a precarious state owing to the ravages of disease and low prices, and many poultry farms had to be discontinued.

In 1937 a method of general assistance to agriculture received Parliamentary approval. This was the Land Fertility Scheme which operated to subsidise the farmer in purchases of lime and basic slag where these were required to improve soil fertility. Arising out of this scheme, a Government-sponsored soil survey for lime and phosphate deficiency followed in 1938.

The effect of the Land Fertility Scheme was to increase steeply the demand on the advisory service for soil analyses: this necessitated the provision of additional staff at Berkeley Square. New field workers were also added for the lime and phosphate deficiency survey, one result of which was the demonstration of widespread potassium shortage in the poorer soils. Other investigations carried out by the section of agriculture and agricultural chemistry during the decade ending in 1939 included an examination, supported by the Bath and West Society, of the nutritive value of hay, silage, fresh herbage and grass from grass driers. Extensive experiments were made to establish the value of dried poultry manure and of a wide range of other organic and inorganic fertilisers.

In Dairy Bacteriology the county rolls of accredited milk producers were superseded in 1935 by the Milk Board's National Accredited Scheme. An immediate result was an increase of 1,753 in a single year in the number of enquiries received by the Adviser. A new laboratory was built and the staff increased to deal with the sampling required in connexion with the designated milk schemes. The Adviser continued his work in perfecting the methylene blue reductase test for use in commercial milk grading.

The Veterinary Advisory Officer developed his activities in close co-operation with the veterinary practitioners throughout the Province, concentrating on those diseases which could not be dealt with by routine procedure. In 1935 the title of his appointment was changed to that of Veterinary Investigation Officer. Special attention was paid to parasitic gastritis and enteritis of farm animals and to the control of liver rot in sheep. In 1938 a scheme of blood tests was instituted for the control of contagious bovine abortion by the maintenance of disease free herds.

The Agricultural Economics Department continued with costings of the various forms of agricultural enterprise in the province. In 1934 the Department initiated, for the Milk Marketing Board, an economic study of management for milk production and in 1937 the costs of grass, hay and concentrates in cattle feeding were studied. Other economic surveys covered pig and poultry production, willow-growing in Somerset and the position of the smaller market gardeners in the Evesham-Pershore area.

Soil surveys of the Lias in Somerset and of the Lower Greensand in Wilts were made in 1932. The benefit of ferric citrate injections for correcting lime-induced chlorosis of fruit trees was demonstrated. In the larger fruit

farms the construction and maintenance of cold and gas stores became a subject of enquiry and a series of investigations on physiological disorders of fruit in relation to orchard conditions was carried out.

Entomological enquiries from fruit growers concerned chiefly apple sawfly, red spider and plum sawfly, and methods of spraying. Dr. Kearns instituted in 1936 a spray programme service to convey to growers, through county advisers, the press, in wireless programmes, etc., warnings of the times when spraying was due and of the spray materials advised. Work on the laboratory evaluation of insecticides started in 1937.

The advisory mycological programme dealt principally with vegetable diseases, and the adviser's assistant was stationed in the Evesham area during the summer months. The seed treatment of various crops with fungicidal dusts was examined, and valuable results were obtained, particularly with peas. In 1935 the Adviser perfected a hot water treatment for the control of mint rust.

The subject of disease control materials and methods figured for the first time in the advisory reports for 1930. Many of the enquiries on this topic arose from manufacturers who were newly entering the field of insecticides and fungicides or who wished to introduce novel materials. Manufacturers showed special interest during the 1930-39 period in the use of oils and of wetters. In 1934 Dr. Martin collaborated with the firms concerned and with the Ministry of Agriculture in the setting up of standard methods of analysis for pest control products and in 1938 he took part in discussions on specifications for the products themselves.

Many pomological enquiries came from intending fruit growers, particularly those requiring information on intensive systems of apple production. The problems of strawberry growing and of blackcurrant production were, throughout the period, the subject of numerous enquiries and visits. Many hundreds of identifications of fruit varieties were carried out annually.

The cider advisory work in Worcester was maintained and that in Dorset and Monmouth was restored in 1938 after a break of some years. The cider competitions came to an end in 1939 after providing a mass of useful data on vintage quality and seasonal effects. The construction of plant and machinery for cider-making was a common subject of enquiry, in particular the choice of metals not subject to corrosion by cider. Disorders of cider, such as sickness and ropiness, were unusually common in 1937.

The advisory work on Fruit Products showed an outstanding rise in 1933, when enquiries were received on a world-wide scale. The products which first aroused interest were dried pomace, pectins, fruit wines and fruit concentrates. By 1936, fruit syrups, squashes and juices for use in milk shakes were the chief subjects of enquiry. In 1938-39, the production of apple juice was the principal topic and a highly successful conference on fruit juices and syrups was held in the summer of 1939. In the same year a communication published by the Imperial Bureau of Horticulture summarised the work done at Long Ashton and elsewhere (7).

The Instructress in Domestic Preservation of Fruit and Vegetables maintained her summer courses, for which the demand always exceeded the available accommodation. Special short courses of instruction in judging produce were also given. In addition, advisory enquiries were dealt with from home and overseas on problems of home canning, bottling, jam and jelly making, and preservation of vegetables by pickling, brining and other methods.

A general survey of the Advisory work of the Bristol centre was included in a Departmental publication issued in 1933 (4).

Number of Enquiries.

If the recorded number of advisory enquiries can be taken as a rough index of the work of the Centre, then it will be seen that this work was almost quadrupled in the decade 1930—39. Enquiries totalled 2,282 in 1930, 4,122 in 1933, 6,545 in 1935, and 7,716 in 1939. (These figures, as before, take no account of the subjects Agricultural Economics and Poultry Pathology and omit routine letters in the Dairy Bacteriology Section.) Broadcasting by members of the Centre made great strides during the decade, and visits by organised parties and by individuals continued to increase year by year. The Centre was on the eve of important new developments when, as had happened 25 years previously, the outbreak of war enforced a drastic modification of plans.

1939—46. The War Period.

Staff.

In 1943 a number of staff changes of major importance occurred. Professor Barker, Director of the Research Station since 1903 and head of the Department of Agriculture and Horticulture, retired and was succeeded by Professor Wallace. In the same year Dr. V. L. S. Charley resigned and, as the Cider Section was thus deprived of scientific staff, Professor Barker agreed to remain responsible for the work on cider. The Fruit Products work was put in charge of Dr. A. Pollard. In the same year Mr. A. W. Ling was appointed Principal of the Seale Hayne Agricultural College, but retained the post of Chief Agricultural Advisory Officer in the Bristol Province. Dr. R. Stewart was made Advisory Chemist with the duty of assisting in the administration of the Berkeley Square Office. An Assistant Veterinary Investigation Officer (Mr. R. W. Roach) was appointed to assist Mr. Menzies.

Other changes of senior staff during the war-time period were the resignation of Miss Duncan in 1940, the appointment of Dr. Miles in 1942 as Advisory Entomologist in succession to Dr. Walton, and the resignation in 1945 of Mr. Pickford, the Instructor in Cider-making. In 1944 Mr. B. Rimmer succeeded Mr. Roach and was in his turn succeeded in 1945 by Mr. A. D. Osborne. Mr. C. J. Hickman was seconded by the A.R.C. to assist the Advisory Mycologist, resigned in 1944 and was followed by Dr. M. Munro, Dr. H. E. Croxall being transferred to the Evesham Laboratory (see below).

In 1945 Dr. Stewart left Berkeley Square and his administrative duties were taken over by Mr. Menzies, while the post of Advisory Chemist was filled by Mr. J. O. Jones.

Subjects.

The revolutionary changes in farming following 1939 are too recent to require detailed description. On the outbreak of war a large measure of Government direction was applied and compulsory ploughing-up orders were put into operation. Importation of fertilizers and feeding stuffs virtually ceased and within two years poultry keeping, pig breeding and sheep farming were greatly reduced. No increase in fruit planting was allowed and glass-houses were diverted to food production. While every practicable step was taken to increase the production of cereals and potatoes, dairy herds were still maintained at pre-war levels and milk production showed practically no reduction. Mechanisation made great strides and farm wages were more than doubled. Economically there was a sudden transition from an era of surpluses

and low prices to one of food shortages and prosperity for the agricultural industry.

The detailed application of Government policy in the various counties was carried out by the County War Agricultural Executive Committees and their officers, with whom the Advisory Service worked in close co-operation. The Chief Advisory Officer represented the Advisory Centre on all the Technical Development Committees of the W.A.E.C.'s, while many of the other advisory officers were also members of these committees. The work of the Agricultural Economics Department increased so rapidly during the war that in 1942 it outgrew the accommodation at Berkeley Square and was given separate offices in Bristol at 79, Woodland Road. The advisory staffs in Entomology and Mycology were also much increased, particularly for wire-worm surveys and vegetable disease investigations, and in 1941 a field laboratory was opened at Evesham to accommodate assistants in Advisory Mycology and Entomology. The Provincial Advisory Conference was revived in 1943 and joint committees of advisory and county staffs were set up to deal, among other topics, with exhibits and publicity.

On the outbreak of war, Dr. Wallace was appointed by the Minister of Agriculture to serve on a scientific Advisory Panel dealing with the food production campaign.

The growing of flax in the Province was revived and particular attention given to its manurial requirements, varietal characteristics, pests and diseases. Willow-growing also became profitable and, in the absence of a Willows Officer, advisory work on this subject was handled by Dr. Kearns.

The Chief Advisory Officer became a liaison officer in all agricultural matters in the South-West Region concerning the Ministry of Information, the Civil Defence authorities and the B.B.C. In the early part of the war he organised the processing of kitchen waste for pig feeding. Another problem dealt with at that time was the maintenance of turf for airfields. The ploughing-up campaign greatly increased the demands for soil analyses, and the requirements of the lime-phosphate survey necessitated increases in the number of field workers. Much attention was paid to local sources of lime and to estimating the "lime value" of basic slag. In view of the need for home-produced feeding stuffs, a silage-making campaign was prosecuted vigorously in the Province and the possibilities of using potatoes and apple pomace in silage were explored. Experiments on mole destruction were made in co-operation with the Research Entomologist.

In Dairy Bacteriology the wartime landmark was the setting up of the National Milk Testing and Advisory Scheme in 1942, after a year in which milk quality had seriously deteriorated. Under this Scheme the Adviser was made responsible to the Ministry of Agriculture for the organisation of sampling and testing throughout the Province. A Standard Platform Rejection Test was put into operation to facilitate the segregation at the creameries of milk of poor keeping quality. The Adviser also paid special attention to the problems of cleansing churns and milking machines. By 1945 area laboratories were operating for routine sampling, which was applied to over 90 per cent. of the total milk supply of the Province.

The reduction in grassland, leading to heavier stocking of pastures, resulted in an increase of problems for the Veterinary Investigation Officer. Grassland became infested with parasitic worms and consequently there were frequent outbreaks of gastritis and enteritis in sheep and cattle. These diseases were particularly serious in calves. Investigations were continued on the control

of mastitis, and the advisory work on poultry was handled by the Veterinary Section after 1940.

The work of the Advisory Economist came into special prominence under wartime conditions when it was necessary to fix the price of the majority of agricultural commodities. Monthly reports were made direct to the Ministry of Agriculture on labour, feeding stuffs and milk production costs. In addition, special investigations (*Enterprise Cost Studies*) were made as required on costs of soft fruit, vegetables, fat cattle, potatoes, poultry, etc. The economist also undertook the analysis of the results of the National Farm Survey carried out on all holdings over five acres by W.A.E.C. officers in 1941-42. Changes in the liability of farmers to income tax led to numerous enquiries on this topic in 1943.

In Horticultural Chemistry the trend of enquiries was largely determined by the ploughing-up campaign and the restrictions in the supply of fertilizers, particularly potassium compounds. Prof. Wallace in 1940 initiated a series of manurial experiments on vegetables in the Vale of Evesham to assist in the adjustment of manuring to wartime conditions. Experiments were also made on the use of other potassium salts as substitutes for the sulphate and on the manurial value of composts, sewage sludges and town refuse. By 1941, investigations of failures of both farm and allotment crops on newly-broken land showed the importance of mineral deficiencies. In addition to widespread potassium deficiency, shortages of boron, manganese and magnesium were demonstrated, the last-named being also prevalent in glasshouse tomatoes. Intensive work on the examination of these problems at Long Ashton enabled large scale demonstrations of the symptoms of mineral deficiencies to be exhibited to W.A.E.C. and other parties in 1943. Surveys of crop deficiencies were carried out throughout the country and methods of supplementing the visual diagnoses by rapid chemical tissue tests were perfected. At the request of the Agricultural Research Council, Dr. Wallace prepared the colour atlas of mineral deficiencies (10) which was published to assist Technical Officers and others in diagnosing causes of crop failures. Soil mapping was continued through the war and land classification maps were produced in preparation for post-war planning schemes.

In Entomology the restriction of new plantings of fruit during the war emphasised the value of reducing as far as possible the depredations of insect pests in the existing fruit acreage. Much of this acreage in the Province is of standard apples owned by farmers who have no spraying equipment. Pest control measures were therefore concentrated on the provision of mobile spray outfits to be operated on a contract basis by the W.A.E.C.'s. Dr. Kearns drew up specifications for the machines and accessories required, gave technical assistance in their assembly, and throughout the war trained teams of spraying supervisors and W.L.A. operators. He also designed an acid sprayer, and, in 1941, gave special assistance to the Bristol Corporation in dealing with pests of blitzed food stores.

Of the pests of agricultural crops, wireworms received outstanding attention. Under Dr. Miles, teams of assistants were sent into every county in the Province and a detailed picture of wireworm populations was built up. Hereford and Wiltshire were shown to be the counties most heavily infested and throughout the Province the chance of newly-ploughed grassland being heavily infested was 1 in 3. After 3-4 years of cultivation infestation was reduced to medium or low in 90% of the fields examined. Other major investigations were on the potato eelworm, pests of brassicas, the control of

flea beetle and the clover eelworm. The Adviser and his staff also assisted the Ministry's inspectors in their Colorado beetle surveys.

The principal factors affecting the incidence of fungus diseases in the war years were the close rotation of straw crops and the intensive cropping in vegetable areas. The enormous increase in onion acreage focussed attention on the diseases of the growing crop and of the stored bulbs. Outdoor tomato growing also developed greatly, bringing in its train the problems of blight and of stem canker. The possibility of utilising the high land of West Somerset for raising stocks of seed potatoes was explored in 1943, and much publicity work was done on potato blight control. Simplified methods were devised for spraying potatoes in allotments and private gardens. Among other diseases investigated by Mr. Ogilvie and his staff were chocolate spot of beans and clover rot. The advisory facilities available at the Evesham field laboratory from 1941 onwards were fully used by the Worcestershire growers and served a most valuable purpose. A new bulletin on vegetable diseases was prepared for the Ministry of Agriculture in 1941 (9).

The advisory work of Dr. Martin on disease control materials and methods was directed in the early years of the war to investigations on dispersible copper preparations for potato spraying. With the occupation of Malay by the Japanese, supplies of derris insecticides were much reduced and attention was given to possible alternatives. The compounding and horticultural uses of D.D.T. became one of the major subjects of enquiry from 1944 onwards. Dr. Martin played a leading part in the launching in 1943 of the scheme for the official approval of proprietary brands of insecticides and fungicides.

The pomological advisory work of the Station was at first largely diverted to the support of the Growmore Campaign, and under the direction of Mr. Hobbis, demonstration allotments were maintained at Long Ashton and in the city of Bristol from 1940 to 1943. Towards the end of the war, when the rehabilitation of fruit-growing assumed importance, the raising from seed of stocks for fruit trees and the provision of disease-free nursery material of soft fruit was undertaken. In 1945 the commercial utilisation of growth-promoting substances formed a major subject of enquiry.

The demand for cider remained at a high level and many advisory enquiries dealt with the problem of retaining sweetness when extra sugar was unobtainable. Another wartime investigation was on the problem of preventing the deterioration of apple pomace, which is a most important source of pectin. The shortage of timber directed attention to new methods of construction of fermentation and storage vessels for cider, using concrete and other substitutes for wood.

In the fruit products section, Dr. Charley's work on black currant and rose hip syrups was rapidly expanded to a commercial scale when the cessation of imports of citrus fruit made it necessary to provide home-produced sources of Vitamin C. Under a Ministry of Health scheme, these fruit syrups were supplied to children and expectant mothers throughout the country. Sweetening materials were in great demand owing to the shortage of sugar, and Dr. Charley prepared an apple treacle in 1940 and a carrot treacle in 1941. In 1942 a local glut of plums in Kent was dealt with by the erection in the orchards of concrete vats in which the fruit was preserved cold by sulphur dioxide.

The Instructress in Domestic Preservation worked in close collaboration with the Women's Institutes in carrying out the scheme for local fruit preservation centres. Special refresher courses and courses of instruction in judging were given in addition to the normal programme.

In 1941, a building at Long Ashton was adapted and fitted as a home kitchen which enabled the teaching work to be carried on at the Research Station. The preservation of fruit by the use of potassium metabisulphite ("Campden tablets") and the types of seals for bottled fruits were among the most frequent sources of enquiry. A series of advisory publications on domestic preservation was prepared for the Ministry, including the well-known Bulletin 21 (8) of which the 6th edition was nine times reprinted between December 1942 and September 1946.

A general account of the advisory work carried on in 1939-43 is included in a pamphlet issued by the Bath and West Society (5).

Number of Enquiries.

The increase in the number of enquiries was less rapid during the war years than in the preceding decade, but a steady rise was maintained to a peak of 10,880 advisory letters in 1943. The suspension of agricultural shows reduced the number of exhibits, but demonstrations in the field greatly increased. At the end of the war, visits by organised parties to the Research Station became very numerous, the totals included in these parties exceeding 2,000 in both 1945 and 1946.

1945-46. TRANSFERS OF STAFF.

Transfer of the Agricultural Economics Section.

On 1st October, 1945, the Agricultural Economics section was separated from the Advisory Centre and transferred to the Economics Department of the University, jointly with the Agricultural Economics section of the South-Western Province (Devon and Cornwall).

Transfers to the N.A.A.S. and other Services.

The following subjects—Agriculture and Agricultural Chemistry, Dairy Bacteriology, Economic Entomology and Economic Mycology—were transferred to the National Agricultural Service on 1st October, 1946. On the same date, Veterinary Science was transferred to the Animal Health Section of the Ministry of Agriculture and the National Milk Testing and Advisory Scheme was also brought under direct Ministry control and included in the Dairy Husbandry branch. In the remaining subjects dealt with in this article—Horticultural Chemistry, Pomology, Fruit Products, Cider and Willows—no appointments had been made specifically for advisory work and no transfer of staff took place.

STAFF LISTS.

For the purposes of record, a list is given below of the senior and assistant staffs in Agricultural Economics as at 30th September, 1945, and in the other transferred sections as at 30th September, 1946.

Agriculture and Agricultural Chemistry.

Chief Advisory Officer (part-time)	..	..	A. W. LING, M.Sc. (Professor of Agriculture in Exeter University College).
Agricultural Chemist	..	..	J. O. JONES, M.Sc.
Assistant Chemist	..	..	E. L. SMITH, B.Sc.
Senior Analyst (Land Fertility Scheme)	..	..	K. SHAW, B.Sc.
Analysts (Land Fertility Scheme)	..	..	W. J. COOK. G. A. GRAY.
Fieldmen (Land Fertility Scheme)	..	..	R. D. RUSSELL, B.Sc. Mrs. W. COLLETT, B.A.
Secretary to Chief Advisory Officer	..	..	Miss M. D. TILLEY.
Laboratory Steward	..	..	Mr. K. H. DUNNING.

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REPORT ON ADVISORY WORK, 1945-46.

With the establishment of the National Agricultural Advisory Service, the Bristol University Advisory Centre ceased to exist on 30th September, 1946. The advisory staffs in Agriculture and Agricultural Chemistry, in Entomology and in Mycology were transferred to the new Service. Veterinary Science was transferred to the Animal Health Section of the Ministry of Agriculture, and the National Milk Testing and Advisory Scheme was also brought under direct Ministry control and included in the Dairy Husbandry Branch. The Dairy Bacteriologist, Assistant Dairy Bacteriologist and certain Area Supervisors were, however, posted to the National Agricultural Advisory Service.

In the remaining subjects dealt with in this report—Horticultural Chemistry, Pomology, Insecticides and Fungicides, Fruit and Vegetable Products, Domestic Preservation, Cider and Willows—no appointments had been made specifically for advisory work and no transfer of staff took place.

The impending change had little effect on the volume of advisory work in 1945-46: the total of advisory letters received amounted to 10,619. Details for individual subjects are listed in the report under the appropriate headings: the summary below gives the county totals with comparable figures from 1941 onwards.

ENQUIRIES SUBMITTED TO THE DEPARTMENT 1941-1946.

		Year ended September 30th.					
		1941	1942	1943	1944	1945	1946
Gloucester (including Bristol)	..	2491	2676	2908	2231	2711	2777
Hereford	.. .. .	196	729	771	438	579	424
Somerset	.. .. .	1479	2039	2491	2076	2394	2625
Wiltshire	.. .. .	1410	1372	1691	1389	1214	2001
Worcester	.. .. .	1010	1506	1491	699	659	779
Other Areas	.. .. .	1776	2030	1528	1429	2376	2013
Totals	.. .. .	8362	10352	10880	8262	9933	10619

The principal increases are shown in Dairy Bacteriology (+ 804), Pomology (+ 229), Economic Mycology (+ 225) and Economic Entomology (+ 230).

In the advisory work in Agricultural Chemistry over 12,000 soils were sampled, the majority at the request of the county W.A.C. officers. A large number of plant specimens were examined visually and by tissue tests for mineral deficiencies. Investigational work was continued on sources of phosphate, mineral content of hay and drying of hay under cover.

The Dairy Bacteriologist calls attention to the help given with advisory work by the area milk laboratories. In all, 17,449 samples were received : the commonest cause of bacteriological faults in milk was inadequate cleansing of utensils and plant. The official test for raw graded milk for 1946 showed the lowest percentage of unsatisfactory samples since the scheme was introduced in 1936.

Veterinary practitioners have made extensive use of the diagnostic services provided by the Veterinary Investigation Officer. Over 42,000 specimens were examined, including 34,384 poultry blood samples. Coccidiosis was prevalent in lambs and cattle, but good results were obtained by Sulphamezathine treatment. Mastitis of cattle was widespread and Fog Fever occurred among Hereford cattle in November. Numerous examples of poultry poisoning by zinc phosphates were recorded.

In advisory work in Pomology, many letters and visits were received from ex-service men wishing to take up commercial horticulture. Identification of fruits and advice on the use of synthetic growth substances were also frequent subjects of enquiry.

Arising out of the special nutritional investigations in Horticultural Chemistry, an unusually large number of requests have been received from home and overseas. Among the subjects included were chemical tissue tests for crop plants, treatment of magnesium deficiency in tomato, substitutes for imported potash, and general problems of soil management and manuring.

A feature of the advisory work in Entomology was the steady increase in farming and market gardening enquiries despite the decrease in sampling for wireworms. The use of D.D.T. preparations gave satisfactory results in the control of pea weevil, flea beetle and asparagus beetle. A preliminary survey has been made of the insects infesting hops. In enquiries relating to fruit entomology the preponderating topic has been spraying practice and spraying equipment.

The adviser in Mycology reports that the wet summer of 1946 led to a high incidence of fungus diseases, particularly take-all of cereals, tuber rots of potatoes, spots and rots of fruit and damping-off of peas. The advisory activities of the Field Laboratory at Evesham continued to expand.

The courses in Domestic Preservation of Fruit and Vegetables were attended by 86 students : in addition, short refresher courses were given for staffs of food advice centres. Tests have been made on certain of the covers used for bottling fruit in jam jars.

In Cider-making, disorders of cider formed a frequent subject of enquiry. Much interest was also shown in the subject of substitutes for wooden containers.

Staff Changes.

Agriculture and Agricultural Chemistry.

Resignations :—Prof. A. W. Ling, M.Sc., Chief Advisory Officer ; Mrs. B. L. Rawcliffe, B.Sc., Field Assistant.

Transfers to National Agricultural Advisory Service :—Mr. J. O. Jones, M.Sc., Agricultural Chemist ; Mr. E. L. Smith, B.Sc., Assistant Chemist ; Mr. K. Shaw, B.Sc., Analyst, Land Fertility ; Mr. W. J. Cook, Analyst, Land Fertility ; Mr. R. D. Russell, B.Sc., Fieldman, Land Fertility ; Mrs. W. Collett, B.A., Fieldman, Land Fertility ; Mr. K. H. Dunning, Laboratory Steward ; Miss M. D. Tilley, Secretary to Chief Adviser.

Dairy Bacteriology.

Transfers to National Agricultural Advisory Service :—Mr. J. W. Egdell, B.Sc., Dairy Bacteriologist ; Miss E. R. Bird, C. & G. Cert., Assistant Bacteriologist ; Miss E. I. Garvie, B.Sc., Area Supervisor ; Miss D. R. Widdas, N.D.D., Area Supervisor ; Miss R. J. Boaz, N.D.D., Area Supervisor ; *Miss J. Campbell Faill, N.D.D., Area Supervisor ; *Miss D. I. Mayes, Dip.Dair., Area Supervisor.

* subsequently seconded to National Milk Testing and Advisory Service.

Transfers to Dairy Husbandry Branch (National Milk Testing and Advisory Service) :—Miss M. Wallis, B.Sc., Area Supervisor ; Mrs. O. G. Smith, Area Supervisor ; Miss R. Gare, Area Supervisor.

Veterinary Science.

Transfers to Animal Health Division :—Mr. D. W. Menzies, B.Sc., M.R.C.V.S., Veterinary Officer ; Mr. A. D. Osborne, M.R.C.V.S., Assistant to Veterinary Officer.

Economic Entomology.

Appointments :—Mr. J. F. Southey, B.A., Junior Scientific Assistant (seconded to Hop Disease Investigations) ; Miss Joan Freeland, B.Sc. (Agric.), Junior Scientific Assistant.

Resignations :—Miss C. M. G. Duthoit, B.A., Senior Scientific Assistant ; Mr. A. J. Lloyd, Ph.D., Senior Scientific Assistant.

Transfers to National Agricultural Advisory Service :—Mr. H. W. Miles, D.Sc., Entomologist ; Mrs. M. Miles, M.Sc., Senior Scientific Assistant ; Mr. F. Raw, B.Sc., Senior Scientific Assistant ; Miss M. J. Haddock, B.A., Senior Scientific Assistant ; Mr. C. H. Hoddell, Instructor in Pest Control Machinery ; Miss E. L. Britton, B.Sc., Junior Scientific Assistant ; Mr. J. F. Southey, B.A., Junior Scientific Assistant ; Mrs. S. M. Wadsworth, Junior Scientific Assistant ; Miss J. Freeland, B.Sc. (Agric.), Junior Scientific Assistant.

Transfer to Research Staff :—Mr. S. H. Bennett, B.Sc., Senior Scientific Assistant.

Economic Mycology.

Transfers to National Agricultural Advisory Service :—Mr. L. Ogilvie, M.A., M.Sc., Mycologist ; Mr. H. E. Croxall, Ph.D., Assistant Mycologist ; Miss M. C. D. Munro, Ph.D., Assistant Mycologist.

Soil Survey.

Transfer to Soil Survey directed from Rothamsted : Mr. D. A. Osmond, Ph.D.

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